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Ecology in Development: A Rationale for Three-Dimensional Policy

Brian Spooner
University of Pennsylvania, spooner@sas.upenn.edu

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Abstract
This combination of theoretical, topical and geographical focus integrates the social and natural science approaches to problems of ecology in development in South-west Asia. Permits coherent treatment, in an argument of reasonable length, of (1) some of the major areas of accumulation of ecological knowledge and insight in relation to development, (2) the changes of emphasis in ecological interests among planners, (3) the development and integration of theory (especially the efforts to straddle the boundaries of sociological and ecological understanding), (4) the changing perceptions of man's relation to nature, and (5) the underlying moral problems of management and welfare. The changes of orientation in each of these arenas over the last decade are treated below not simply as another stage of progress to confirm our faith in the perfectibility of man, but as a function of a larger historical process of increasing awareness and communication, the beginnings of which would have to be sought at least as far back as the Industrial Revolution.

Disciplines
Anthropology | Human Ecology | Social and Behavioral Sciences

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Preface

The rise of human ecology

During the 1970s anxiety about the environment not only deepened but changed in quality and emphasis. Compared with the 1960s, less attention is now given to population growth and more to energy demands. More significantly, there is a growing tendency to make correlations between the quality of the environment and the quality of human life. Ecological, economic, and social decline are more often discussed as though they are inter-related (although the relationship is rarely well argued). Environmental problems now engage a greater mix of disciplines and professions than a decade ago, and in each group of specialists there is a greater awareness of other disciplinary orientations to similar problems and (dare we hope?) a new readiness to enter into genuine dialogue across disciplinary and professional boundaries.

This trend in the great ecological debate that began in the 1950s manifests itself in both scientific and political forums in the form of an evolving concern with "the human factor" in ecology and development. This concern is evident in popular literature on economic development and resource management from various parts of the developing and the developed world, and is reflected in the changing relationship between the so-called "basic" and "applied" approaches to research and in the background dialogue between the natural and the social sciences. But although the ideals of resource management are now somewhat more tempered by considerations of human interests and local perceptions (than, say, in the fifties), and applied ecology is more and more commonly understood to include a measure of social science, little progress has yet been made in the determination of acceptable standards in potentially conflicting policy areas, such as ecology and human wellbeing in relation to each other, let alone in integrating these concerns generally. However, in spite of the occupational divisions and other vested interests that constrain such intellectual reorientation and hamper the associated reformulation of problems and reorganization of scientific effort, a supra-professional and supra-disciplinary specialization has begun to develop, and a degree of integration of these newly related interests is already discernible. The fact that it is not yet possible to put a generally accepted name on it - though "human ecology" is often pressed into service, and for want of a better term is sometimes used in what follows - shows that its identity is barely formed and its independence scarcely viable. But there seems little doubt that it is gathering momentum and therefore warrants careful attention. This essay is concerned with some of the assumptions from which it is developing, and with its direction and significance.

A framework for discussion

The term "ecology" was introduced by Haeckel in 1869. His purpose was to focus attention on relationships, especially relationships with the environment, rather than on organisms and species. The coinage was taken from the Greek for household (oikos) and suggested a broader interdisciplinary perspective on phenomena in context. In practice, it has proved very difficult to cover the structure of the "house," as well as the relationships of all the

occupants with it and with each other, in one analysis. Ecology has, by and large, been natural ecology at its broadest. Where human activities have been included in the subject matter of ecological studies (for the most part a recent development), they have been studied naturalistically, or as though they were a function of natural processes, rather than an integral part of a larger universe.

Dissatisfaction with this situation has been growing for some time, but little progress has been made in the direction of improvement. This essay seeks to show a way- perhaps not a new way, but one that has not yet been shown sufficiently clearly. Ecology is conceived here three-dimensionally, as the integrated study of three independent but interrelated types of process: natural. social and cultural. These three adjectives are already known to the general reader, but their exact meaning may not be clear. Or, even if they appear only too familiar, their connotations may still be vague and confusing. The significance of the distinctions between them should become clearer in the course of this essay, but in the meantime it may suffice to distinguish them by the following glosses. Briefly, "natural" comprehends physical and biological; "social" denotes phenomena that derive from the combination of demographic variables and the stochastic interaction of human individuals in the ad hoc and ad hominem arrangements they make as they run their daily lives; and "cultural" refers to the meanings that govern and move people as they interact.

We generally think that the natural dimension of research covers all animate and inanimate relationships except insofar as they are upstaged by social or cultural factors. If we cannot predict natural relationships, we believe that our failure is due to an inadequacy in our science, or (more likely) to the intrusion of human activity, which is inherently unpredictable; we believe interaction in the natural dimension to be inherently predictable. The social dimension of research is like the natural in that it depends primarily on observation. But, despite the mathematical sophistication of demography, which covers an important component of the social, it differs from the natural in that on any significant scale it defies prediction. It may be regarded as the product of the interaction of the natural and the cultural. Finally, the cultural is the most intractable. To understand it, it is necessary to enter people's minds, and distinguish from their individual psychologies the symbols, concepts and stories that grow and develop and change according to unique principles as a common heritage.

None of these three dimensions is independent of or comprehensible apart from the others. But since none is determined by or fully dependent on the others either, and since each moves in a different tempo, it is essential to separate them for analytical purposes in order to avoid the common forms of reductionism which imply that a political movement or a change in values is predictable in the same way as, for example, the evaporation of water.

In what follows it is assumed that the only way to ensure adequate attention to each of these three dimensions of reality and human experience is to differentiate them explicitly from the start. Only if we first argue each separately in its own right will it eventually be possible to arrive at a balanced and integrated solution of ecological and socio-economic problems in development.

The choice of material

Development is conceived here generally to include all modern planning and project implementation which is designed to increase productivity, to modernize traditional systems, and to raise living standards, especially in the Third World, irrespective of the possibility of direct benefits to the investor or donor. The argument for the differentiation of three dimensions in this context should ideally be made on the basis of a careful evaluation of accumulated experience. However, to attempt to review all the ecologically oriented work in the natural and social sciences and its application in development over the last decade would be over-ambitious. The same objective may, perhaps, be achieved by narrowing the focus to a sample of areas of research and application which have been especially important during this period. Because of the impact of the Sahelian drought on ecological thought, I have chosen to concentrate on work generated by the special problems of arid and semi-arid lands - the world's dry lands - and especially desertification. Within that corpus, I am mainly concerned with questions raised by the growing demand for attention to the human factor. The argument is illustrated with cases from South-west Asia, where I have had considerable field experience. They are also appropriate on the more

objective criteria of length of historical record and density of population, as well as economic and general human significance.

The aim of this monograph

This combination of theoretical, topical and geographical focus integrates the social and natural science approaches to problems of ecology in development in South-west Asia. Permits coherent treatment, in an argument of reasonable length, of (1) some of the major areas of accumulation of ecological knowledge and insight in relation to development, (2) the changes of emphasis in ecological interests among planners, (3) the development and integration of theory (especially the efforts to straddle the boundaries of sociological and ecological understanding), (4) the changing perceptions of man's relation to nature, and (5) the underlying moral problems of management and welfare. The changes of orientation in each of these arenas over the last decade are treated below not simply as another stage of progress to confirm our faith in the perfectibility of man, but as a function of a larger historical process of increasing awareness and communication, the beginnings of which would have to be sought at least as far back as the Industrial Revolution.

Acknowledgements

The argument and the data presented here have grown together over the past five years or so during my association with a number of different projects, especially the Turan Programme (see below, chapter three); and the final result, whatever its faults and deficiencies, demands the acknowledgement of assistance and inspiration from a variety of sources. Published and other written sources which I have consciously used are of course cited and listed at the end. But apart from reading I have benefited incalculably from interaction with scientists and planners from a wide range of backgrounds in the contexts of work with the Department of the Environment (Tehran), the Central Arid Zone Research Institute (Jodhpur), and various projects sponsored by UNESCO's Programme on Man and the Biosphere (MAB), the United Nations Environment Programme (UNEP), the Economic and Social Commission for Asia and the Pacific (ESCAP), and the United Nations University (UNU). Among individuals, I am particularly grateful to Douglas J. Merrey and Stephen Sandford, both for help and discussion and for allowing me to use their work on the Punjab (Pakistan) and on Turan (Iran) respectively to support my argument in chapter three. The associates of the Turan Programme have influenced my thinking in many cases far beyond the immediate implications of their personal work in the field, and I take this opportunity to express my gratitude to all of them, and especially to Lee Horne and Mary Martin with whom I have worked most closely. Both of them read through the penultimate draft and made detailed comments which helped me to eliminate many inconsistencies and infelicities.

More generally, during the last five years or so as I developed the ideas reflected here, I believe I have learned most from Drs. J.A. Mabbutt, H.S. Mann and J.P.S. Uberoi, in the disciplinary, administrative and epistemological dimensions of my interests. My ideas have been worked out in discussion with students and colleagues at the University of Pennsylvania and elsewhere, and some of the material was included in a paper presented at The Regional Seminar on Alternative Patterns of Development and Life Styles in Asia and the Pacific sponsored by UNEP and ESCAP in Bangkok, August 14 -18, 1979, and another at the Anthropology Department Seminar at Yale University in February 1982. I am grateful for all the opportunities for stimulation and edification afforded by these connections, though I may not always have known how to make the most of them. I hope the resulting essay, despite its imperfections, will succeed in reflecting without too much distortion the growing global awareness of human nature especially in its social and cultural dimensions - in relation to the physical and biological bases of life.

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I. Introductory

Any consideration of ecology in development raises a number of problems. Some of these problems are relatively tangible: ecological, economic or administrative. But many of them are more difficult to grasp and define, and are moral or political in nature. Such problems generally receive little explicit, open discussion. The reason probably lies in the fact that the relationship between our epistemology and our experience is paradoxical: the rules which we develop to explain natural processes defy attempts to extend them into the social or cultural sphere. We "know" how ecological processes work, but somehow our experience presents us with unexpected results. When we attempt to rationalize our experience in order to deal with the practical problems of development, we are confronted with a dilemma: we have to choose and make trade-offs between the priorities of resource management and human welfare.

The dilemma is simply the practical transformation of the paradox. The paradox suffuses the whole constellation of problems of ecology in development and confuses our thinking about basic issues. But it is most acute for the planner, whose task is complicated further by the fact that the relationship between intellectual awareness and practical effort has been changing. In planning circles most discussion is concerned with the design and implementation of practical measures for the solution of the immediate, obvious problems of production and distribution. If it also takes care of long-term resource management, that is a bonus. But little attention is given to the different ways of thinking, feeling, and wanting that underlie those problems in target populations.

The paradox is intellectual; the dilemma is practical. Each is a different representation of the same basic contradiction. The solution of the one entails the resolution of the other. Both ecologists and development planners are less and less able to avoid the dilemma, but instead of confronting it they deal with it in the manner of superficial patching and fail to resolve the paradox. Rather than face up to the fundamental rethinking it requires, they generally still manage to ignore it. This chapter focuses on the relationship between the paradox and the dilemma as two sides of a coin, with the purpose of forming a basis for treating them together in the chapters that follow and making it more difficult for them to be treated separately in the future. The first section spells out the paradox. The second treats the dilemma and seeks to illuminate the social context in which it has recently begun to work itself out.

I. The paradox

From whichever angle we approach the various ecological problems that arise in development (and there are several possible angles: whether as scientist, engineer, or planner; as politician, farmer, or shepherd) sooner or later our expectations are frustrated as we confront one or another face of a general paradox. Paradoxes are characteristically difficult to tie down in clear succinct statements. The following approaches to the present

paradox pursue some of its implications and consequences as a prelude to tracing some highlights of its history during the 1970s.

Ecology and development

Recent decades have been characterized by rising social consciousness. This historical phenomenon, which is related to (but not entirely explained by) the changing technology of communication (such as transistor radios, satellite television, computer hookups), has been evident almost everywhere to a greater or lesser degree, but it has taken different forms in different social and cultural situations. In the West, a major focus of this consciousness has been on the diagnosis of continuing decline in the productivity of the world's renewable natural resources, which is generally seen as the result of human activity, and as a threat to the quality of human experience in the future. People now (mostly other people) are destroying the resource base of people in the future (especially of our descendants). In the developing countries, which after all constitute the larger part of the world's population and are therefore also responsible for the major proportion of all human activity, concern about ecological decline is much less evident. In its place is found an increasingly vehement demand for improvement of living conditions today through more even distribution of existing resources.

If human activity causes ecological decline, it also lowers the limits of what can realistically be aimed for through development to improve the conditions of human activity. This conflict between behaviour and ambition underlies much political activity, and it is especially evident in the international arena (See, for example, Schulz 1982). But the conflict derives from a paradox which lies at a deeper level of consciousness: where we process and classify (without thinking) all information and experience as it comes in.

Ecology and development are inescapably interrelated. Particular development, insofar as it is directed towards increased food and other crop production, begs the ecological question of the long-term productivity of resources. Ecological processes do frustrate development (although there are also other reasons for the disappointment of the development record). But ecological constraints are relatively easy to objectify and identify. So, since ecology is firmly rooted in the hard sciences, whose laws all accept and respect, it should be possible to persuade people - all people: planners, politicians, farmers to accede to their imperatives and develop within the confines they prescribe. Why then does ecology continue to threaten us and to exact Malthusian penalties? Why does development planning often misread or otherwise overshoot ecological limits, and contribute to crashes such as the economically and socially unprecedented Sahelian disaster of the early 1970s?

These questions have often been answered in terms of local ignorance, navet&#65533;, and greed, but such answers are too simple to be satisfactory. Development (conceived as the planned accomplishment of economic and social change) now demands the operationalisation of ecology (in the sense of what has been learned of the evolution and organisation of ecosystemic relations). However, this logical demand is made against the background of a paradigmatic shift in our general conception of science and society.

The meaning of our concepts of science, society and technology have been changing as one aspect of the accelerating social change experienced by a growing proportion of the world community in the second half of this century. Recently science appears to enjoy less and less academic freedom; technology is no longer believed to be essentially transferable, and society threatens to break out of control, like the uncovered contents of Pandora's box, in ways that were unthinkable less than fifty years ago. The social context of scientific concept and technological solution, as they are learned and used, receives increasing attention. The growth and spread of both political awareness and the means of communication have led to changes in the stakes and the opportunities. as well as the values and the symbols, that give paradigmatic structure to everyday life everywhere, at the local, national and international levels of interaction.

When the movement for global development got underway in the 1950s, it was based on the assumption that technology somewhat narrowly conceived) had the answers to the world's production problems, and all that was needed to implement them was adequate investment; by the time technology came up against new problems, science would have developed the conceptual basis for answering them too. After a while (with the benefit of

some hindsight) it became clear that two types of constraint were frustrating the typical development project- if not before completion, then before its planned benefits could be realized. One of these was ecology, the natural processes within which the resource base was embedded; the other was society, the social processes within which the necessary manpower was embedded. For, society, as much as nature, resists men's plans; it is not wax at the hands of the scientist. the planner, the legislator (Passmore 1974, 100).

Natural and social science, pure and applied

Ecology, as the holistic study of the natural environment, had an obvious place among the sciences that backed the movement for the economic development of natural resources. But it was integrated into the planning process only slowly because the ecologist tended to act as a brake on the ambitions of the engineer, forcing him to think in terms of the long-term natural implications of the current project, when he would rather leave that to subsequent operators and move on himself to meet new and more exciting challenges. (The hundred-year history of the development of irrigation in the Punjab, recounted briefly in chapter 3 below, provides abundant examples of this tendency of the engineering profession.)

The study of society - social science - did not take its place among the sciences that backed development (except for a few relatively independent or peripheral branches, such as economics). Apart from a number of individual exceptions, in general sociologists were unaccustomed to thinking in terms of the practical implications of their accumulated knowledge, and sociology has in fact rarely been represented as the holistic study of human experience in such a way that it could meet ecology - the holistic study of nature - on equal terms.

It cannot be overstressed that, unlike the ecologist, the sociologist stands within his own subject matter, and is himself a part of it, in a way that other scientists - pure or applied, including the ecologist and the engineer - are not. The tendency to try to neutralise the implications of this condition in the name of science have paradoxically emasculated sociology as a science, especially within the development context. Social science became divided into schools, which were partly a reflection of the divisions of the society the scientists belonged to, and differed with regard to the feasibility of development.

It is not surprising, therefore, that it has taken social science longer than ecology to become involved in the development effort. Most sociological work on development as a process (as distinct from what has been written about underdevelopment as a condition) has consisted of rationalisation of the effort under the heading of modernization theory, based on unquestioned assumptions of progress, rather than what was needed explanation of what was happening, of success and failure. The root of this aspect of the paradox lies in a lack of scientific awareness of social process, even a refusal to acknowledge it (a kind of social equivalent of psychological repression), and in the related backwardness of social science (for which there are of course interesting social and historical explanations, which are beyond the scope of this essay).

It should by now be clear that one precondition for the resolution of our paradox lies in the integration scientific discovery, technological capability and sociological understanding, in relation to the constraints of ecology and the ambitions of development. But such integration is not easy to accomplish. This essay is written against the background of the concern with this general problem, but has as its specific focus the progress that has been made in understanding the relationship between human activity and natural processes as a basis for reconciling human ambitions with both ecological and social constraints in the development effort; in other words, it is concerned with the practical understanding of the human component of the ecosystem, and of the natural component in human (social) thinking. A little elucidation of the anticipated resolution is necessary here before moving on in the next chapter to a survey of the process of changing orientations.

The three dimensions of ecology

Ecology has become a popular word. But it means different things to different people. In ordinary parlance which can never be entirely divorced from scientific usage it is inexact and emotive. So what does ecology mean for practical purposes?

Ecology has three dimensions of meaning:

1) a natural dimension - it directs attention to the systemic relationships that compose concrete, natural reality;
2) a social or political dimension - it has different social referents according to where the actor stands in relation to others in an ecosystemic whole, in which all manoeuvre for advantage or power; and
3) a cultural or ideological dimension - it stands for a value (it is good), and has the quality and power of a symbol (it moves us).

But we must bear in mind that it is in the nature of symbols not to give exact or unitary or unequivocal meaning (See, for example, Leach 1976). We should be suspicious, therefore, of any pretension that ecology gives complete and clear answers, and careful to distinguish among the different dimensions of its usage.

Holism and selectivity in science and in common sense

How do these three dimensions of the meaning of ecology work in our minds? Meaning is the property of something we understand (though there may be different levels of meaning and we may not be equally conscious of all of them). What we understand is experience, and we understand it through ordering. We order through selecting; and we select in categories. But it is often difficult to see how our categories were established, because categories of thought commonly have to do with the symbolic rather than the scientific dimension of our mental activity. They are not always determined rationally. Thought inherently moves in symbols, but builds in oppositions, which render categories and taxonomies. One of the tasks of science (broadly conceived), and therefore of scientific ecology, is continually to question the boundaries of the categories, in order to minimize the constraints that those boundaries and their selectivity impose on our thought.

In the cultural dimension, more and more people were attracted to the conceptual category of ecology in the 1960s and 70s because of its symbolic value. But as they focused on the star of ecology they did not realize that the meaning they attributed to it was conditioned by their own social context. For this reason every discussion of ecological reality casts some opposing social group in the role of villains. At this symbolic level of meaning ecology functions as a banner to rally one social group for political action against those it sees as rivals.

It is generally assumed that natural ecological processes conform to natural laws, that in cases where we have failed to anticipate particular ecological results the fault lies not in the laws but in our own imperfect understanding of them or of the conditions under which they operate. On the other hand, there is no general agreement about the dynamics of human activities or the causes underlying historical process. Although there have been attempts at formulating laws of human behaviour to complement natural laws, the results have been unconvincing and unsuccessful. But how can human behaviour be lawless if the biological organisms that generate it, as well as its physical environment, both conform to laws? Resolution of this fundamental paradox of human ecology lies in the understanding that natural laws are formulated on the basis of human perception and perception is not a totally complete and accurate representation of reality. Natural laws are still being formulated and improved.

The paradox can be resolved if we admit the full significance of the role of perception in our science and the fact that perception varies individually (for psychological reasons) and between various groupings of people (for social and cultural reasons). The psychological point is generally granted, and psychology no longer has any difficulty in holding its own in interdisciplinary debate. But the social point remains unconceded, even it often seems unrecognized. We concentrate here, therefore, on juxtaposing the social and cultural dimensions with the natural.

Not only science, but all human perception is selective. The degree to which it is selective, and what it selects, varies from one individual to another, and especially from one social group to another (even within one general cultural environment), and from one historical period to another. The conclusion that our scientifically-formulated natural laws may change with time and experience is obvious and inevitable. If the laws may change, it is morally indefensible to use them as a basis for the adjudication of human rights! Of course, if they are the best we have we are bound to make at least tentative use of them, but we should be careful always to bear in mind their limitations rather than be tempted to make political capital out of the presently exaggerated value they enjoy.

Selectivity in ecological observation allows the formulation of natural laws to account for physical and biological phenomena. Selectivity in the observation of human behaviour has in comparison been quite unsuccessful in reducing the diversity of actual activity to the order of predictive laws and, more seriously, it is open to moral objection on the basis of human rights. The resolution of this aspect of the paradox lies not simply in accepting that culture is of a different order from nature, but once again that it is substantially closer to the observer. Because he is more intimate with cultural phenomena. the observer is less able to discriminate what he sees. It is an example of the well known commonsense problem of the woods and the trees.

There is not space here to pursue further this question of the relativity of natural laws and ask what determines the actual forms of perceptual variation, though in what follows the problem is not entirely ignored. However, this preliminary juxtaposition of scientific approaches to ecology and society suffices to introduce the central intellectual problem of resource management in relation to human welfare.

As a result of the accelerated social and economic change of recent decades it is now much easier to see the relationship between society, intellectual climate and the emphases of scientific research. The paradox lies in our inadequate understanding of the relationship between the paradigm of thought and belief on the one hand and the context of behaviour and intent on the other. Scientific and intellectual paradigms and social and political behaviour are inter-related in a dialectical process that also interacts with natural processes. Each is continuously affected (but not determined) by the other, but they do not necessarily move in step. Symbols hover over both. Paradigms change slowly. Society undergoes continual internal reorganization and readjustment. Whether or not social change therefore drags scientific thought feet first into new paradigms, it is more useful because less often attempted - to concentrate here on the social dimension, on the question: What is social change doing, at the global level, to the context of scientific research on dryland ecology as it relates to dryland development problems? In brief, we acknowledge here that ecology operates as a symbol and as a natural process and set out to deal with the problems that arise at the social level, where both nature and symbol are manipulated for advantage by individuals and by groups.

The essential paradox

When we define or characterize a problem as "ecological" we fall into the assumption that it can be solved according to natural laws. We may not yet know those laws but we believe that they are discoverable. Such laws may be imperfectly understood but knowledge of them is increasing fast and seems in most cases to be sufficient for our purposes. But when ecological processes lead to situations that we diagnose

as ecological problems, the immediate or efficient cause lies generally not in nature but in human activities. The interaction of psychological, behavioural, cultural and historical factors that produces human activities is inadequately understood, and prescription of corrective measures is complicated by moral considerations which are involved in the relationship between the local population and the specialist or investigator. We arrive, therefore, immediately at a paradox in our (often unexpressed) assumptions that the natural component of a problem is determined by laws, whereas the socio-cultural component is not, but the socio-cultural component is part of the natural!

Most scientific rationalizations of this apparent contradiction depend on suppression of either the natural or the socio-cultural dimension. Most commonly they take the course of granting the natural priority over the socio-

cultural, and of assuming that human activities are somehow contained in the natural. But this assumption is no longer always allowed. It is being replaced by the idea that since natural laws are pronounced by people they are dependent on human perception. This is slowly causing a significant epistemological shift which allows us to find new answers to the problems confronting us by identifying different universes of analysis according to how the universe of the problem is defined by different disciplines.

The ecologist tends to deal with this situation in terms of levels of organization. Unfortunately, however, he generally assumes a hierarchy of levels (Cf. Odum 1975, p. 4). Hierarchy implies rigidity, and domination, and especially the priority of certain types of phenomena (usually natural) over others. The available evidence does not always support these implications.

Here we argue rather for equality of opportunity (cf. Spooner 1982a). Each discipline, each approach, is valid only insofar as it can demonstrate its validity in the context of the case at hand. Symbolic, social and natural processes are inter-related, certainly; but the relationship is neither hierarchical nor systemic. The resolution of the paradox that frustrates the human ecologist, and the solution to the problems of ecology in development, lie in pursuing each dimension in its own right, while giving due credit to the effects on the others, where they can be demonstrated.

II. The process

Although we have always known that man operates individually, socially and historically in an ecosystemic context, it is only relatively recently that we have seriously included people in ecological studies. This inclusion involves a change in our conception of nature. It will be interesting to trace some of the ingredients of this change.

The subsumption of man into ecology

Despite the change in its conception, ecology remains a guiding star because it has become a symbol, and it is in the nature of a symbol to mean different things to different people at different times. (By contrast desertification, which underwent popularization in the mid-1970s, was - despite considerable official effort from some quarters - never successfully rendered into a symbol, and seems never to have become fully effective as a stimulus of political action. This failure may perhaps be explained by the fact that the concept was too specific, whereas successful symbols are vague, multivocal, open to different meanings and applications.) But by inserting people explicitly into the conception of ecology we have disturbed the order of that conception. To begin with, therefore. we went through a period of ecological imperialism, when the symbolic value of ecology allowed political sanctions to ecologists to determine what was right or wrong for various other sectors of the population. But as it became clear that contemporary human problems (as distinct from problems in the study of evolution) could not successfully be treated in the framework of adaptation, in the way the condition of other species was generally explained, the framework had to be modified. So long as we force ourselves to make human behaviour fit existing patterns of ecological thought we often have no option but to brand it as maladaptive (which implies a moral judgment), or to do violence to the patterns (which leads to scientific error), or else to be intolerably selective in what we choose to observe - which some are prepared to be. (See for example, Rappaport 1967, 1971a, who explains human behaviour as a mechanistic component of ecological processes in the New Guinea Highlands, without also explaining why the same should not be true of human behaviour in the populations of London or New York City.)

In this type of explanation we are usually faced with the problem "which people," especially "us?" or "them?" or both? For as soon as we look closely at any social situation we can distinguish different interests and different points of view. If we choose to explain only "them," we run into moral problems; if both, we run into problems of objectivity. We are in sight of a resolution of the paradox, only to be faced with a dilemma. The process of changing orientations is a story of manoeuvres in relation to this dilemma, generated by the underlying paradox.

The argument of this essay is set in the story of the last decade or so of the growing awareness of these social and epistemological problems. While as scientists we seek to work out solutions to these problems at the philosophical level, as people we are (along with everyone else) working them out in everyday life (the Lebenswelt of the phenomenologists) in continuous manoeuvre and negotiation about where we stand in relation to each other with regard to the natural and cultural furniture of existence. These activities comprise a dimension of the larger political process, projected onto a new symbol ecology.

It is important to notice the relationship between ecology, politics and epistemology, because it is the key to the explanation of why and how the conception of ecology is changing. The process of reorientation we are concerned with derives from the dialectical interaction of the political and symbolic orders of human life in its natural context. Just as our paradox extends into practical and theoretical, political and moral dimensions, so does the process of change. Not only scientific but also professional and lay perceptions of the problems in the availability of resources and in the quality of the environment and of human life have evolved during the 1970s in ways that, if we study them carefully, may improve our understanding of both scientific and political process generally. These perceptions have become more closely interrelated and more synoptic. They are better informed by a combination of research developments in pedology, hydrology, biology, public health, history, economics, sociology, and anthropology that result from cross-disciplinary interaction: These developments raise new problems that can only be solved by further interaction. Generally, they give grounds for optimism about the future of the relationship between human life and the natural environment. Much of what we have to say here, therefore, relates to bridge building between different disciplinary approaches to certain ecological problems. The results may not be secure, but they are promising.

The subsumption of ecology into the political process

The relationship between human activity and natural processes is dominated by spatial and temporal variation in human needs for food, fibre and energy and in the repertoire of technologies for processing natural resources to satisfy these needs. Relative demand in relation to exploitable resources in each of these categories is a major determining factor in international relations. Besides ecology, population, food, and energy have recently enjoyed symbolic status and functioned as political rallying points. During the 1970s energy become relatively more significant and food and population relatively less. The Third World divided into the Third and the Fourth. The constellation of relationships among different social elements that generate public opinion in the more advanced industrial nations, and between them and national units of the Second, Third and Fourth worlds underwent a number of shifts, in which changes in the price of oil, and to a lesser extent some other commodities, have been both a cause and an effect. These changes in the political economy of the world make better sense when viewed in historical perspective. They are a stage in a longer process which may be usefully seen as starting in the middle of the nineteenth century when the ideas of rationalism, Marxism, and anti-imperialism began to oppose the accepted liberal, capitalist, and Christian mode of thought on which European dominance had been based. This process is now culminating in a period when Arabias, Nigerias and Brazils (each with their share of ecological problems), based on different systems of ideas, play significant and independent international roles alongside the more fully industrialized nations.

Although scientific research may be constrained by a general intellectual paradigm more than by the direct influence of social factors, within that paradigm there can be considerable conflict and variety in the balance of power in relation to particular problems between different politically vocal sectors or lobbies. In relation to the ecology debate, such sectors divide up in several ways: the natural and the social sciences, academia and the professions, planners and politicians. During the 1970s (a decade of intensive discussion, research, analysis, and application, boosted by the sudden increase of Third-World capital and demand resulting from the increase in oil

prices in 1973) progress in the solution of problems was spectacular. But shifts in the relations of the major participants in the debate and the scientific and non-scientific causes of those shifts may, if studied carefully, lead to a greater self-awareness and a more successful organization of people in relation to resources for the future.

The diverse factors determining the choice, design, progress and success of ecological projects, pure and applied, demonstrate the main lesson of the recent decade: that directions of scientific research and the application of results are determined in ways similar to national elections or the conclusion of international agreements. Relative political feasibility is in practice more significant than values (that appear more or less absolute) of resource management and human welfare. Among these factors are the political interests of donor countries, the internal politics of the United Nations system (See Schulz 1982 and the politics of the peer review system as operated, for example, by the US National Science Foundation. It is worth noting here that the concept of academic freedom was formulated in a particular social context, one which was relatively stable and in which change tended to be dissimulated and suppressed. Although the concept still survives in practice it is being eroded more and more noticeably by the pressures of social change, which tend not only to influence (if not to constrain or direct) the formulation of research proposals but to change the social status of academic endeavor.

The socio-economic process that has led to the production of more Ph.D.s than could be absorbed in the universities or in their own national economies is a further factor affecting the directions of research. The different surplus numbers of Ph.D.s in different academic disciplines is yet another. Scientists trained for research are obliged to seek employment in organizations that focus their activities in directions determined by the political process. Specific political developments that deserve mention in this context, because they have generated new position for social-science Ph.D.s, are legislation by the United States Congress requiring that (1) USAID projects must help small farmers, and (2) environmental impact statements (later interpreted to include social impact) should be included in all project documents for government-financed projects. Similar reorientations to development, bearing implications for resource management and human welfare, have also occurred in other countries. Although recent policy changes have withdrawn some of this support for social science it is unlikely that the paradigmatic shift in the direction of social awareness will prove in the long term to have been arrested.

Ecological interests generally have become more and more explicitly embroiled in politics and economics. The ecological movement began in earnest in the 1960s when the comforts and expectations of the more affluent sectors of industrialized nations seemed threatened politically and economically by population growth abroad and environmentally by pollution at home. Since the threat was felt in different degrees by people in different places and different social positions, ecological problems were translated into political problems. By the late 1960s, frustration at lack of progress in solving the problems had led to a generalized revulsion against the over-exploitation of nature and its transformation by technology. The symbolic power of ecology reached its height at the beginning of the 1970s, when both popular magazines and specialized journals were publishing articles prophesying doom and preaching politically unrealistic conservation. Some of them bordered on mysticism and the apotheosis of nature. It was forgotten that reverence for nature enshrined in religious traditions had not ensured good resource management in ancient Greece or in modern Japan (Cf. Passmore 1974, p. 13 and Bennett 1976, pp. 141-145). However, other forces were building up that would lead to reformulation of the problems in such a way that the political conflict under the banner of ecology would become more international.

This debate over who wanted to conserve whose resources for whom has been joined most conspicuously in the series of United Nations conferences beginning with Environment in Stockholm in 1972.

Ecology as a movement

Under such titles as "Man: Planetary Disease" (MacHarg, 1971), the more extreme semi-popular articles of a decade ago imply that present human interests should be subordinated to general ecological productivity and diversity in the name of future generations. Their professed eco-centricity (which must itself presumably be explained historically rather than in terms of evolution or ecosystems) distorts the findings of scientific ecology and disguises the fact that their prescription tends to preserve their own social position in relation to less

fortunate positions, because they do not distinguish between the various human interests that would or would not be affected. Such writers forgot that if it is likely that future generations will suffer from long term reduction of ecological productivity caused by current generations, it is even more likely that they will suffer from adverse social and economic conditions deriving similarly from our present situation. History-which of course we continue to make - leads directly to the society of the future and along the way not only reshapes but redefines its environment. If the ecological decline perceived today results from current social processes, surely the most obvious strategy to pursue for the achievement of optimum conditions in the future is the modification of those social processes presumably by the improvement of social conditions. But the eco-centric argument assumes the opposite: that it is possible to find a political solution now to an ecological problem predicted for the future. Success in this direction requires the type of faith that makes revolutions. Unfortunately, however, although faith and ideology - which are more concerned with the future than the present - are potent forces in politics, revolutions are generally successful only when current conditions are in some way intolerable. Current land use and industrial practices that are implicated in ecological decline are likely to change only in response to immediate social and economic pressures which may or may not derive ultimately from the ecological processes. The relationship between ecological and political ideals is therefore generally at best indirect; at worst they are incompatible. In any case their integration is extremely difficult to organize.

Ecology in administration and planning

Although by the mid-1970s attention to the human factor, as well as to ecological implications, was explicitly required in most development projects, no clear statement on what should satisfy this requirement has yet been worked out. Most of the literature argues at least implicitly for policies of enforcement (Cf. for example, Le Hour  ou 1977b) as the only feasible strategy for ensuring that local populations go along with management regimes designed and recommended by experts. The assumption that, by definition, the expert knows better than the local farmer or shepherd is integral to the argument. Reduced to its essential steps, this argument still most commonly runs: Ecological decline leads to impoverishment and decline in health and wellbeing in the immediate population as well as reduction in productivity and carrying capacity for the world as a whole. It is caused by human misuse of resources due either to ignorance or to personal greed or to lack of organization and leadership. We, the specialists, have the scientific knowledge and technical expertise to reverse these processes, but since we are powerless to change the human behaviour that is at fault and to command the cooperation of local populations, we are unable to implement them. it is therefore necessary by legislation and other ancillary means to organize enforcement of the rehabilitation programmes we devise.

It is interesting that although this enforcement approach pervaded the development field generally, it began to give way in the early 1970s to a philosophy of participation except where ecology was concerned. The principle that the target populations of development projects may be considered generally to have the right to participate in decisions affecting their own future has not been extended to areas in which ecology is involved because (the argument runs) in ecology the experts are the guardians of all the world's natural resources for the sake of future generations of all populations. Ecologists have been allowed a greater degree of infallibility and greater authority than other types of people. We are required to accept without adequate proof the principle that the experts always know best, despite the fact that they are known to have made mistakes in the past and that the ecological knowledge of local populations has not been scientifically investigated and tested; it is simply assumed to be the philosophical basis of behaviour that causes degradation of natural resources, and therefore to be inferior.

Apart from these considerations, enforcement is often difficult to organize efficiently. In the case of grazing ratios and the use of vegetation for fuel the difficulty is often insurmountable. So long as the perceptions of the local populations differ from those of the experts and the enforcing agency, any type of enforcement may be economically unfeasible. For instance, over a large area of isolated rangeland, especially if it is mountainous, traditional pastoralists cannot be efficiently monitored, let alone coerced, on a long term basis, except at enormous cost.

An alternative argument that has been emerging in recent years. It runs: Exogenous economic and political factors, such as technological assistance and the terms of trade, are changing local strategies of resource

management and perceptions of the environment. These strategies and perceptions are based on a complex indigenous (some would say ethno-ecological) store of knowledge which is inseparably linked to the human resource that is essential for efficient exploitation of an area's ecological productivity. Strategies and perceptions derive from the culture and structure of the local population. Planned intervention in local man-land relationships, however desirable or necessary it may appear in the interests of long-term ecological viability, must be extremely sensitive to any possible adverse effects on the cultural integrity of the local population, disturbance of which might bring about cultural and ecological decline, and consequently also social dissolution and human suffering.

The transition from the first of these two arguments to the second is complex. The first provides a relatively clear guide for action (though it has a poor record of success}; the second, at least until it is developed further, does not. But the most important difference between them lies in their implicit definition of variables. The ecologist focuses his attention on biological populations and defines geographical units in terms of ecosystems. A local population sees its situation in terms of its own- social boundaries (which generally overlap the boundaries of ecosystems) and of economic connections in a larger human use system. Its perceptions should be assessed in the context of the history of the larger cultural and linguistic area of which it forms a part. Other parties to the debate have different perspectives and draw different geographical boundaries around the same problem. For example, the planner may be primarily concerned with the national economy. This difference of perspective varies according to social position and again according to scientific discipline, so that an ecological problem becomes (as the arena of debate is opened up) an economic problem, a political problem, and a religious problem. If the argument is continued and the local ecological problem is considered in the larger geographical context defined in terms of overall political economy, ecological decline may be assessed against the background of technological evolution, and of Kondratieff waves of long-term macroeconomic fluctuation (See, for example, Rose 1981).

Even if it is still possible to argue that there are ecological values that are absolute according to criteria of productivity and species diversity, once the significance of the human factor is accepted an ecosystem takes on a historical dimension within which present trends must be assessed in relation to the past, and future possibilities in relation to the conditioning of the past. A realistic evaluation of an ecological problem demands reconstruction of the history of the natural resources and the environment in relation to the history of land use. Proof of over-grazing in the current year is not sufficient to condemn a land use system. On the other hand, a perfect record does not guarantee that a land use system is ecologically safe and will never lead to degradation (See Sandford 1982). Whether or not a land-use system remains adjusted or adapted in the long term to the productivity of the relevant ecosystem, in the sense that the relationship between them will remain in equilibrium, it is always vulnerable to exogenous factors such as fluctuations in the terms of trade or changes in national policy (especially as it affects investment). Examples of the role of these factors are given in the case studies in chapter three below. The role of ecology in administration and planning depends on economic, political and organizational factors in the first place and on ecological factors only secondarily.

A preview of the following chapters

The biggest ecological headlines in the 1970s were related to the Green Revolution and the Sahelian Drought. The one was generally positive and optimistic, an apparent victory for technology (though not entirely without disappointments). The other was negative, pessimistic, suggesting the inadequacy of technology, political mobilisation, and aid in the face of Malthusian limits imposed by stochastic climatic fluctuation. The current status of ecological understanding and technological ability- research and application - is inevitably assessed against the background of these recent experiences. In their aftermath, what have we learned from field projects and from theoretical synthesis? In what follows. answers to these questions are pursued in relation to dry lands only, on the basis of material generated mostly by the Sahelian drought and the UN General Assembly's call for a conference and an international campaign to combat desertification. First, in chapter two, a brief introduction is given to some of the basic concepts of human ecology, illustrating the degree to which they help or hinder the progress of ecology in development; this review is followed in the second half of the chapter by a survey of some of the attempts that have been made during the 1970s to reorient the field of human ecology, an assessment in the

light of the argument so far, and an outline of the implications and possible roads to improvement. Chapter three investigates two special cases: one of irrigation in South-west Asia, with special reference to the Punjab in Pakistan; the other of pastoralism on the Iranian Plateau, with special reference to Iran. The final chapter recapitulates the argument in a reassessment and rationalization of changing orientations towards ecology in development, and suggests implications for ecological and development planning and future research.

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2. Retrospective

The first step in an assessment of where we stand presently in the current of thought about our relationship with the natural environment and what we might be able to do about it is to find our bearings and develop a perspective. The best perspective for the study of a process is likely to be a historical one. In this chapter we look back over the last decade and trace some of the events that mark the gradual accretion of change in attitude. But first it will be well to review some of the basic ideas or assumptions in terms of which the slowly-changing discourse about natural resources has proceeded through the 1970s.

I. Assumptions

All fields of human endeavour- scientific, administrative, commercial or domestic - develop general orientations. These orientations, which are often now called paradigms (a convenient derivation from Kuhn, 1962), and might more felicitously be called discourses (in similar derivation from Foucault, 1970) derive from the accumulation of concepts which are formulated in the process of explaining temporal and spatial relationships and, generally, ordering information. These groups of concepts are not necessarily mutually compatible or consistent and the argument that interrelates them is often not explicitly worked out. Within a discipline some concepts tend to take priority over others for reasons of historical precedent or intellectual fashion. No orientation is totally coherent and there is plenty of room for legitimate difference of opinion among specialists emphasising different concepts within one general orientation. Ecology is such an orientation. Human ecology is fast becoming another.

On ecology and human ecology

Human ecology is more diverse than most such orientations, because its practitioners scarcely constitute a unitary profession. They come from a range of different backgrounds. Of the scientific traditions they would claim as their heritage, biological ecology would be among the most prominent, though a significant number of them are primarily trained in the social rather than the natural sciences. Within the social sciences they span the range of possibilities from the more philosophical and theoretical to the applied and practical, from anthropology and political science to civil engineering and public health. Whatever their primary training, they tend to accept unquestioningly a number of concepts from biological ecology as the basis of their explanatory repertoire. They rely on these concepts to identify themselves as ecologists, but since they are taking each concept out of context, they run the risk of distorting it and of being rejected by the disciplines that fathered the concepts (which is not to imply that natural ecology has not made significant borrowings from the social sciences; see for example the discussions in Rapport and Turner 1977 and Richerson 1977).

It will be useful here to discuss briefly a few of these basic concepts in order to demonstrate some of the dangers that they present. Awareness of these dangers has increased significantly among the various brands of human ecologists over the last decade. The major concepts selected for treatment here are "adaptation" and "ecosystem." But these also raise questions about others, such as "niche," "population," "energy flow," "equilibrium," "succession," "carrying capacity," "the tragedy of the commons," and "rationality," each of which is introduced briefly here and elsewhere, as appropriate.

On adaptation

The most basic assumption of ecology has been characterised usefully by Barry Commoner in his popular book, *The Closing Circle* (1971, p. 29): "The first law of ecology," he writes, is that "everything is connected to everything else." But if we proceed from such an assumption, how can we determine for practical purposes where, and how, particular chains of causation begin ?

There is no satisfactory general answer to the first part of this question. The accepted answer to the second is "by adaptation." The two questions may be combined by asking who or what adapts first. In attempting to answer this it would help to understand how adaptation works. For this question - outside the study of biological evolution there is as yet no satisfactory answer.

The difficulty is much greater when the chain of causation moves from physical and biological to social and cultural factors, since there is no generally-accepted explanatory framework common to both the natural and the social sciences. Moreover, natural scientists either assume human behaviour can be changed (and that if politicians cannot change it, social scientists should be able to), or they attempt to apply natural science theory in the explanation of human behaviour. Sometimes, somewhat illogically, they do both. At the same time they have become dependent on a number of social concepts, such as "community." Social scientists, on the other hand, have been tempted to borrow concepts from the natural sciences. especially "ecosystem" and "adaptation." However, although some studies based on such borrowing have been elegant tours de force they have generally been inadequate as explanations. But most social scientists have either ignored the ecological context of human behaviour or understood it only imperfectly, and they have sometimes justified this inattention by insisting that social and cultural processes cannot be explained by reducing them to another order of phenomena, whether biological, physical, or even psychological. There obviously is a relationship, but the exact nature of it not amenable to generalization.

Some ecological problems derive directly from changes in natural phenomena, such as precipitation patterns. In this case human activity may be blamed only insofar as it does not in due course adapt to the new situation (unless it can be shown that human activity somehow caused the change in precipitation, as in the current hypothesis that increasing accumulation of carbon dioxide in the atmosphere, resulting from the increasing consumption of fossil fuels, is inducing climatic change that will include among other things higher temperatures and increased occurrence of drought in the sub-tropical arid zone). In fact most ecological problems are considered by both social and natural scientists to begin with increases in human activity, especially as a result of population growth. But the term most commonly used to discuss the relationship between human activity and the natural conditions is "adaptation"!

The concept of adaptation begs the question of mal-adaptation. Otherwise, how would any problems arise? But if both adaptation and mal-adaptation occur, how do we know when to expect one and when the other? If we cannot know, then neither is equivalent to a law. In an applied science, especially, neither concept is useful unless we can predict when one will occur and when the other. The combination of genetics and the theory of natural selection makes it possible to deal with this problem in evolutionary biology, but (so far at least) we have no equivalent in the other fields of biology. let alone in the social sciences.

Adaptation is generally defined in both the natural and the social sciences as a process whereby an organism seemingly fits better into its environment and way of life. (See, for example, Bateson 1979, p. 227.) The mechanisms whereby biological adaptation occurs (as natural selection of phenotypes, due to environmental

pressures, leads to change in genotypes) by genetic transmission of traits and mutation are reasonably well understood. But when the concept is transferred to the cultural sphere acceptable analogies are difficult to find and little progress has yet been made in the study of them. One extreme position, typical of those who assume adaptation everywhere regardless of all the evidence of mal-adaptation, or who at any rate do not try to explain the incidence of mal-adaptation, re-defines the concept in the framework of systems analysis as the process by which organisms or groups of organisms, through responsive changes in their states, structures, or compositions, maintain homeostasis in and among themselves in the face of both short term environmental fluctuations and long term changes in the composition or structure of their environments (Rapport 1971a, p. 60; cf. 1971b, pp. 23-24).

Such a definition presumably places most entrepreneurial activity beyond the pale of acceptable behavior by dubbing it maladaptive - unless it defines homeostasis so broadly as to comprehend somehow all social change! Perhaps more importantly, it presumably deals only with behaviour, taking no account of intent. A more generally acceptable position, typified by Sahlins (at one stage, 1964), simply uses the concept to draw attention to the effects of non-cultural constraints on human behavior or on cultural processes, whether these constraints are physical, biological, social. demographic or historical. In fact, Sahlins makes the point that the most important constraints on human behaviour are often historical, in that people are seldom able to do more than they have been taught. It is worth noting that the genetic information that sets limits on biological adaptation is of course also in a sense historical (Sahlins 1964, p. 136).

A simple ethnographic example will help us to put these definitions in perspective:
Quite commonly, Eskimo culture is cited as an apt, if somewhat extreme, example of how man's cultural capacity allows him to adapt to even the harshest circumstances. At such a gross level of analysis, such statements are unquestionably true, for it is apparent that culture does make the difference between life and death for the Eskimo as it most probably does for every other human being today. (Burnham 1973, p. 93)

The evaluation of culture as adaptive in this sense cannot help us to explain why some behaviour interacts with natural processes more homeostatically, or with greater apparent conservationist concern, than others.

In the context of development the most serious problem with the scientific concept of adaptation lies in its implicit consignment of all human activity which is involved in degradation to the category of maladaptive and (by a short step) irrational behaviour. Attention to the human factor often stops here. It should of course minimally be extended to the point of suggesting an explanation for the irrationality.

Probably the best that can be said in the present state of our understanding is that in the explanation of human behaviour and of culture the concept of adaptation is not very useful. For all behaviour is adaptive in the sense that in a given situation each individual responds to a range of factors (which include both the historical and the psychological) that are not so much ecological or environmental, as contextual. An individual or a group adapts its behaviour to a set of cultural, social and natural factors in which it may see the cultural or social factors as more immediate or important. Over-grazing may make good economic sense for particular individuals or groups in particular situations. but it is likely to be branded as maladaptive and thus irrational. Since enforcement is often unsuccessful in the long run, it might be more promising to investigate the causes of such maladaptive behaviour and seek to remove them by legislating incentives or disincentives. But our consciousness is so pervaded and conditioned by the values of science that we tend to assume adaptation even when we have evidence against it. Like ecology, therefore, adaptation can become a symbol around which we rally but it may not provide an unequivocal basis for action. It is equated with conscious rational or unconscious useful behaviour, but it does not provide a workable recipe for planning.

On ecosystem

The main problem with the concept of adaptation lies in our inability to locate the mechanism. The need to focus on a particular mechanism always implies to some extent the definition of a unit of analysis. In biological ecology, adaptation is the mechanism that relates the individual to its immediate environment and the population

to its niche - a subset of an ecosystem, which includes all the biologically and physically relevant environment. In biological ecology any investigation to a greater or lesser extent implies ecosystemic boundaries to the enquiry. "Ecosystem" was coined from "ecological system" by A.G. Tansiey in 1935 to denote "not only the organism complex but also the whole complex of physical factors forming what we call the environment of the biome - the habitat factors in the widest sense."

Many attempts to develop some form of human ecology have disregarded the discontinuity between biology and culture and have given ecosystem priority in defining the context of social and cultural factors. This approach has been successfully promoted by the brothers Eugene P. Odum and Howard T. Odum in imaginative ways but ways that are nevertheless severely limiting, in that they discount the dynamics of social and cultural processes and (in the case of Howard T.) reduce all activity to processes of energy flow, which is translated into quantitative terms. These terms are only superficially meaningful, but are treated as though they are an end in themselves. The use of the term ecosystem in this sense is the result of coalescence with general systems theory, which has been very influential in social science. Rapport once again provides an excellent example. He seeks to perfect his ecological approach to culture by subsuming even the "numinous" into a systems analysis of an entire socio-natural system of a small isolated community in Highland New Guinea:
the sacred and the numinous form part of an encompassing cybernetic loop which maintains homeostasis among variables critical to the group's survival (1971b, p. 39).

But when the social and cultural dimensions are taken into account, "ecosystem" as a framework for the analysis of man-environment relations becomes a straightjacket that deprives us of any flexibility, especially in the treatment of the non-behavioural factors. When we move from theory to application the social and cultural factors can no longer be contained in the straight-jacket: it is no longer possible to ignore them.

The problems of application

Attempts to deal with human behaviour ecologically by arguing from concepts derived from natural science, however elegant some of them may be, are in the final analysis, if not before, disappointing, for several reasons: They imply that equilibrium is normal and change is abnormal. They distort the context of behaviour by defining it in exclusively natural (that is, non-social) terms. They imply that motivation has not changed in the course of either evolution or history. And finally, they imply an assumption that although human technology has continuously increased carrying capacity since the Palaeolithic and currently continues to do so, sometime in the relatively near future it will cease to be able to increase it further.

Because of this disappointment it is legitimate to argue that ecological science forfeits any right it may claim to demand intervention in the lives of "non-scientific" populations. Where intervention is against their wishes as it commonly is- it raises moral issues. The relationship between populations will, of course, anyway continue to be determined not by science but in the political process, where morals are commonly trumped by politics. So. if science is to be used as a bargaining counter in the political process the arguments should be made in terms of a theory of ecological degradation that does not beg moral questions, and does not impugn particular social groups. Human ecology needs "no-fault" theories.

Even without the human factor ecological systems are so enormously complex that it is virtually impossible to comprehend them entirely in a coherent description or analysis. Bateson (1979) and Commoner (1971) both emphasised this problem of complexity and in different ways suggested that any interference is, therefore, likely to be dangerous. Interference is, however, a matter of degree and human populations are now so large, so ubiquitous, and so ecologically dominant that a policy of noninterference is unrealistic. But since any intervention is bound to be selective and partial, favouring some groups and disrupting others, it must be organized from a more broadly-based and open-minded effort at comprehension. This aspect of the human factor is the most important and most neglected: since even our scientific understanding of ecological situations is embedded in particular socio-cultural and historical contexts, definitions and assessments often vary according to the social vantage point and identity of the investigator. This is not to say that ecological trends and causes are not real, but that any one interpretation of them is likely to be partial and relative.

The answer to this problem is not to despair or retreat into mysticism (as Passmore, 1974, pp. 173-176, has characterized some of the more extreme expressions of the ecology movement), but rather to seek always a range of interpretations of any given situation, from individuals related to it in different ways, and to work on the synthesising of those interpretations. Since any interpretation is likely to be (to at least some extent) derived from reality, but is different and partial insofar as it is conditioned by both individual and collective experience and identity, the larger the number of interpretations that get fed into the political process, the closer the final synthesis is likely to be to reality.

A helpful methodological analogy may be found surprisingly, perhaps - in a discussion of the nature of myth by Levi-Strauss. Arguing from the example of the Oedipus myth, he demonstrates (1963, pp. 212-213) that it is not possible to determine the true version of a myth. The way to get as close as possible to what is significant in the myth is to collect and correlate and synthesize as many versions as possible. Further:
At this point the objection may be raised that the task is impossible to perform, since we can only work with known versions. Is it not possible that a new version might alter the picture? This is true enough if only one or two versions are available. but the objection becomes theoretical as soon as a reasonably large number have been recorded. Let us make this point clear by a comparison. If the furniture of a room and its arrangement were known to us only through its reflection in two mirrors placed on opposite walls, we should theoretically dispose of an almost infinite number of mirror images which would provide us with a complete knowledge. However, should the two mirrors be obliquely set, the number of mirror images would become very small; nevertheless, four or five such images would very likely give us, if not complete information, at least a sufficient coverage so that we would feel sure that no large piece of furniture is missing in our description. (Levi-Strauss 1963, pp. 214-215)

The best analysis of an ecological situation involving human populations is similarly one based on the largest (but not necessarily a complete) census of the opinions of people- both scientists and others - who are in some way related to the issue, either intellectually, professionally or personally. It should be noted that any consensus is likely to be influenced by public policy, though not necessarily in favour of it. An analysis of the relationship between a grazing regime and an area of rangeland will be conditioned not only by the relative social values of the pastoralists and investigators. but by the place of pastoralism in public policy- which, in turn, depends on the degree of participation of the various parties in the formulation of public policy and on the historical context. For example, in cases such as Iran, where government is dominated by people from settled agricultural backgrounds, whose cultural heritage includes fear of raiding by nomadic pastoralists, policy has tended to discriminate against traditional forms of pastoralism despite the economic demand for pastoral produce. In other countries such as Somalia and Jordan, or Botswana, where traditional pastoralists have a closer relationship with the government, policies towards traditional forms of pastoralism are more positive despite the existence of similar ecological problems. The solution to the moral problem of the human factor, therefore, lies in providing the broadest cross-section of opinion to inform public policy, representing scientific understanding, technological capability and relevant cultural values.

This brief discussion of some of the basic assumptions of ecology as applied to human problems has focused on the lack of fit with particular situations to which they might be applied. The remainder of this chapter reviews the consequences of this lack of fit in the intellectual history of the recent decade.

II. Reorientation

For the present purpose it is convenient to divide the history of the world into three phases of increasing diffusion of information and intellectual awareness. In the first, which extends up to the Enlightenment, natural,

social and symbolic phenomena were for the great majority of people all explained alike in terms of religious faith. In the second phase, beginning in the seventeenth century, the use of mathematical reasoning replaced religion in this function at an accelerating rate, to the point where its superiority became generally established for all argumentative purposes, both in the West and by various processes of exportation throughout most of the world, thus determining a disciplinary hierarchy in scientific endeavours, according to the degree to which mathematical argument could be applied. In this process natural, social and cultural or symbolic phenomena were separated out as a function of intellectual reliance on a particular type of reasoning, which works best with the natural, and inadequately with the other two (especially the symbolic). In the third phase, with the growing autonomy and equality of nations since the middle of the twentieth century, the political process has led to a demand for the equitable distribution and application of scientific knowledge in ways which take account of variation in social conditions and symbolic values.

Society and culture are now coming into their own as independent dimensions in our perception of the problems to which science and technology are applied. Here we are concerned with a small part of this third phase (which is still only beginning and has reached identifiable proportions perhaps only in the last decade) in the growing awareness of inequity in the distribution of natural resources among social groups of all kinds, and the implications for future generations.

In the second phase, problems were defined scientifically in terms of systems. The spread of general systems theory in the middle of this century represents the culmination of this paradigm. Explanation of natural processes was pursued in terms of ecosystems which were assumed to evolve by adaptation in the direction of equilibrium. Change was orderly and proceeded according to the laws of succession, which were disturbed only by exogenous factors. In the case of dry lands the principal exogenous factor was precipitation, or its absence. As the third phase develops, however, it becomes clear that the larger political economy, in the social dimension, and the spread of consumer values, in the cultural dimension, are exogenous factors with similar disruptive potential. As our attention is taken more and more by the disruptiveness of these various natural and human exogenous factors the systems view of the world appears less and less adequate for our purposes.

From a static to a historical perspective

The rising consciousness of the role of larger political and economic forces and of changes in values is causing a major reorientation in ecology and development. But the basic assumptions of adaptation and equilibrium are still strong. Science, and intellectual endeavour generally, consist of the imposition of order on observed phenomena. The importance of equilibrium in our thinking lies in the fact that it is a relatively simple form of order. It is difficult for us to find a better one to replace it with. The science of ecology is founded upon it.

Ecology has to do with equilibria of various types, and with their achievement, as in the concept of succession, and with the quasi-mechanistic balance between subsystems, populations and (by extension) societies. Ecology is generally ahistorical. in the sense that it is concerned with the evolution, rather than the history, of ecosystems. It is true that for similar reasons - the imperative need to impose satisfactory order- much social science has also been not only ahistorical, but even (because of its need to distinguish itself from history) anti-historical. Although the recent experience of socio-economic change has inevitably led to some historical awareness, nothing has yet replaced equilibrium as an implicit conceptual framework of analysis. New concepts are needed to facilitate the paradigmatic shift. Unfortunately, the available social theories of change all seem partial and unsatisfactory. But although the ecologists' paradigm was not weakened so easily by historical change and they are not forced so insistently by the unpredictability of everyday life to question their framework as are social scientists, nevertheless the theoretical emphasis in ecology appears to have shifted over the last ten years from synchronic descriptive analysis of ecosystems to a more dynamic focus on evolution and natural selection.

Such a trend is promising because it should lead away from the phase-two conception of ecological systems and human disruption to a phase-three orientation in terms of ecological process and social cause. For example, where ecological problems have developed in the aftermath of exogenous technological change in the waterlogging and salinisation of large areas in the Punjab (See chapter 3), it had been taken for granted that the

local society was adaptive (even though it was accused of causing the problem), and resilient (though it was obviously suffering from the consequences). Only recently has some attention been given to social forces and cultural values as independent variables interacting with the natural processes (See Merrey 1982).

In the study of ecosystems, where the productivity of natural resources is reduced as the consequence of activities in the human use system that incorporated them, the ecologist's reaction has commonly been to focus on the degraded resource. The degradation is then attributed to the immediate cause in the form of the social group exploiting it, as in many cases of traditional pastoralists and degraded rangelands. Desertification is acknowledged to be caused by social factors, but no attention is paid to their etiology. Remedies are generally designed by focusing on the symptoms of specific desertification problems (for example, reduction in the quantity and quality of vegetation), and by attempting to rearrange the more immediate social factors in relation to them. Judging by the record, this approach commonly fails to lead to a satisfactory solution and, besides, often brings about new adverse social factors which may accelerate the original process. Cause is translated easily into fault, and central authorities with large urban constituencies are comfortably indulged in their prejudices against marginal rural populations. Cultural discrimination of urban against rural increases; the population concerned suffers further reduction in its range of economic options and tends to become an increased burden on its immediate natural resources.

The ecologist focuses on natural processes and sees the fault in the behaviour of the human population which failed to reorganize its activities in the way prescribed. The social scientist is invited in to devise ways to encourage the people to confine their activities within boundaries prescribed by the ecologist. Until recently, most social scientists working in development have tended to accept the ecologists' terms of reference and have sought to apply their expertise as a service in the larger programme. Some now seek to reformulate the terms of reference, and redefine the situation in terms of the interests of the human population, in order to develop an ecologically satisfactory strategy that will serve those interests. In dealing with desertification in particular the social scientist is more likely than the ecologist to look for the ultimate social cause, which is often outside the affected area. It is unfortunate, however, that few social scientists have sufficient ecological awareness to be able to interact persuasively with ecologists.

This problem of difference in orientation between disciplines is simply a permutation of the difference in values - the conflict of interest- between different social groups generally, and is replicated again in the difference between the orientations of "basic" and "applied" research. It is generally allowed that involvement in applied work may condition values and compromise scientific objectivity. It tends to be overlooked that the implicit assumptions underlying the positions of basic research are cultural values that are by no means absolute, and may therefore be morally questionable. The arguments for and against capital punishment or abortion, for example, are based on differences in moral assumptions which no scientific argument can resolve. Scientific judgment faces a similar moral problem in ecology, but it seldom becomes apparent - except when human populations are involved. The introduction of "experts" (in the parlance of the UN system) into any situation where there is already a conflict of interest over the solution of ecological problems changes the moral and therefore also the political balance, either by reinforcing the position of one group vis-�-vis the rest, or by adding a new group. Each group formulates its solution to the general problem in terms of its perception of nature, which is in turn based on a combination of social and cultural heritage and self-interest.

The problem of integrating the explanation of cultural and natural processes in a single theoretical framework is complicated by historical factors on the social-science as well as the natural-science side. Pre-Darwinian evolutionary theory, which was not immediately replaced either by Darwinism or by genetic theory and still survives here and there in popular writing, was extended in the 19th century to describe a series of stages of cultural evolution, culminating in Victorian society. Revulsion against this model of human evolution which arbitrarily categorized, and failed to explain, spatial and temporal variation, contributed to the theoretical isolation of the social sciences which continues still. This isolation was therefore to a large extent self-imposed, and attempts to bring the social sciences out of it have so far met with little success. One of the more noteworthy attempts is that known variously as cultural ecology, human ecology or ecological anthropology-which is where social science enters the present argument.

Cultural ecology (as the ecological approach from within cultural anthropology has most commonly been known) was defined by Julian Steward as the study of "the adaptive processes by which the nature of society and an unpredictable number of features of culture are affected by the basic adjustment through which man utilizes a given environment" (in Tax 1953, p. 243, quoted in Netting 1977,p. 6). It has been most successful in the study of relatively simple technologies. Since man has occupied most dry lands from the earliest technological stages of history, it is not surprising that many dryland areas have been exploited by pastoralism and irrigation since the beginnings of those technologies. These less-than-ideal habitats have, of course, been exploited mainly by behavioural or cultural, rather than physiological or genetic adaptation, and are excellent material for long-term social science research. But studies in cultural ecology, despite their intrinsic interest, have generally failed to function as bridges between the social and the natural sciences. There are two reasons for this failure. First, instead of trying to integrate social theory with explanations of natural processes, cultural ecologists have sought to explain social processes either by reference to natural factors or in naturalistic terms. Second, by adopting the ecologists' systemic assumptions of equilibrium and homeostasis, which reinforced some a historical tendencies in their own tradition, they have ignored the historical background of their subject matter which might have forced them to take more seriously the ecologists' assessment of ecological degradation and to attempt to explain change. Therefore cultural ecology, whatever the benefits of some of its products (for example, explanation of certain cultural or social similarities in similar habitats) could not provide the basis for a dialogue between the social and the natural sciences.

In order to avoid any possibility of misunderstanding it may be worth restating that there is no intention here to question the reality of ecological processes apart from specific cultural perceptions of them. Neither is it meant to suggest that basic ecological research (as it has been pursued in isolation from social problems and the social sciences) is misguided. The problem is to bring both sides together.

There are in fact signs that a *rapprochement* of sorts is finally on the way. Though still somewhat faint, these signs are especially discernible in work sponsored by certain agencies of the UN system where the political pressure to reconcile scientific and political opinion is possibly greatest. The accumulation of data from observation, description and analysis of ecosystemic processes in the 1970s, which had been stimulated by the International Biological Programme (IBP) and continues to be supported by UNESCO's Programme on Man and the Biosphere (MAB), has been impressive. Dryland research, in particular, received an important boost when the United Nations General Assembly passed a resolution in December 1974 to organize a United Nations Conference on Desertification (UNCOD). UNCOD suddenly became the Maecenas of dryland ecologythough not for long. Meanwhile, ecology had become a historical issue and would never again be convincingly treatable outside its historical context.

The Conference was initiated in the atmosphere of urgency generated by the human tragedies that followed the Sahelian drought, but its subject matter was defined to include a larger set of problems that had for some time been causing increasing concern. The Conference Secretariat commissioned a series of studies to synthesise the state of knowledge on all these problems. These studies (See UNCOD 1977a) were organized in terms of climate, technology, ecological change and the social and demographic aspects of desertification. Other studies (See Mabbutt and Floret 1980) were commissioned by the Secretariat and by other UN agencies and participating countries at the Secretariat's request. To demonstrate experience with and lessons learned from the application of this knowledge, a third series of studies investigated the feasibility of tackling selected problems transnationally. Other agencies - UN, international, national, and non-governmental - contributed complementary studies.

The General Assembly, and following it, the UNCOD Secretariat and the writers of the various studies, all made the point that the human factor should be given special attention. It is important to point out, however, that none of these studies actually succeeded in integrating the human factor into a general ecological argument. The political determination for integration was there, but not the epistemological framework, and not the methodological mechanism. However, during the 1970s two landmarks appeared in the progress of social-science thought in relation to ecological problems. Both are deceptively simple, but their implications are important for the future of the ecology debate. The first is the formulation by a group of social scientists (invited to develop a social science contribution to MAB) that "human use systems" are not coterminous with ecosystems

(UNESCO 1974). The second is the concept of the "ecological transition" (Bennett 1976). The two concepts are complementary and it is worth while spelling out their implications here in a little more detail.

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From ecosystem to human use system

The formulation of the human use system as the spatial universe of analysis, to balance the ecologists' ecosystem, answered the immediate need for a conceptual framework that would include all the human variables relevant to a particular question, which could not always be meaningfully explained within the same geographical boundaries as the related natural processes. This was the first stage in the emancipation of ecologically-oriented social science from socially-inappropriate ecological concepts. However, it is necessary to point out that it was still only the first stage, because it continued to imply a materialist explanation of human behaviour. in that it is based on technology and economics and pays no attention to the role of ideas. But even this degree of emancipation from natural science was difficult to follow through.

The "ecological transition" provided a dynamic explanation of the relationship between ecosystems and human use systems. In evolutionary perspective. intensification of economic activity leads to increase in the use of money and breaks down the boundaries of autarky between populations, involving them more and more in wider and wider economic universes, as they develop tastes for, and become dependent upon, new products and the resources of a larger geographical area. The process is generally accompanied by significant and sustained growth in population. It leads inevitably to a change in relationships between the population and the natural resources on which it depends. If an autarkic population depletes its resources, it faces ecological ruin and subsequent disintegration, unless it can migrate to, or develop, new resources. Once it makes the transition to a level of socio-economic integration where the economic or other opportunities in a larger social universe are more important than the immediate natural resources. rationality no longer necessarily dictates conservationist techniques of exploitation. Bennett's ecological transition is a description and interpretation of this process in evolutionary terms.

It is interesting to note that it is only in those developed countries which have progressed furthest beyond the ecological transition that a reaction has set in calling for conservation; and it is only in the smallest societies with the simplest material technologies that a plausible case can be made for inherent conservationism. Most of the societies we are concerned with in the context of development fall somewhere in between these two extremes. These ecological differences are significant, and the ecological transition enhances our understanding of them. It is important to remember, however, that at each stage of the transition people's orientation towards the environment is explainable only as a projection of their view of their relationships with each other.

Before the transition, the level of social complexity rarely reaches the stage where bureaucratic forms begin to develop. The typical small community organizes its use of resources in the idiom of kinship and descent. Ethnographic cases where group solidarity takes precedence over individual acquisitiveness and ambition are common. In recent years it has been argued that in this condition, where ownership of resources is not individualized, there is a natural tendency to over-exploit, because each individual assumes that what he does not consume himself will be consumed by others who will thereby gain economic advantage at his expense. This idea has been promoted in the phrase "the tragedy of the commons" (Hardin 1968; see also Crowe 1972 and other papers in Hardin and Baden 1977) as having significant explanatory power in the analysis of environmental problems. Like adaptation, however, its application is limited since there are traditional pastoral situtions (such as among the Kirghiz nomads in northeast Afghanistan. described by Shahrani. 1979) where over-grazing has been successfully avoided, and there are situations with private ownership (such as the history of agriculture in the American West) where degradation has been significant.

As a population passes through this transition, however, the level and complexity of organization change and there are parallel cultural changes - changes, that is, in ways of thinking. The market becomes the integrating factor in a greatly enlarged socio-economic universe. Kinship and community are no longer sufficient organizing

principles; there is a greater risk of a tragedy of the commons (and private ownership does not necessarily mitigate it); and administrative forms of social organization are developed for specific productive purposes, from small agricultural enterprises to large multinational corporations. This qualitative change in forms of organization is a factor of great significance in the evolution of man-environment relations, and it will be necessary to return to it later.

The ecological transition explains why people are generally not, and should not be expected to be, natural conservationists. Desertification has forced itself on our consciousness in the aftermath of a drought that coincided with a particular stage of growth - growth in population and in demand, when resources in vulnerable areas were already under pressure and many populations had become less responsive to the condition of their resources and more responsive to market systems centred outside their immediate resource base. The relationship between the population and its resources - the resources that are undergoing desertification - is less direct and exclusive than it was in earlier historical periods. It may of course never have been totally exclusive.

Where desertification developed in geological time as a result of climatic change, it is beyond our ability to reverse. Where it is known to have developed from premodern land use practices, it has, in many cases, either recovered, or the area has been re-colonised by means of different technologies. But where desertification develops from pressure of human use now, even in the least developed parts of the world, it is less and less relatable to specific production decisions taken by individuals either on behalf of themselves or of groups, and more and more to systemic changes that comprehend large areas, only part of which may be vulnerable.

The ecological transition is seen in the progressive incorporation of nature into human frames of purpose and action - which is rapidly eliminating the cases of distinctive, isolated tribal adaptations to natural phenomena that have been a specialty of the anthropologist. The historical trend is now toward much larger systems in which the behaviour of tribal people or peasants toward natural resources is determined as much or more by social forces beyond their control as it is by internal concepts and needs. (Bennett 1976, p. 3)

Desertification becomes a danger when the populations of vulnerable areas are subsumed into socio-cultural systems which are not co-terminous with those areas, and which restrict their freedom to respond directly to fluctuations in the productivity of the renewable natural resources on which they depend; or, more specifically, when the socio-economic networks of human use cross a particular threshold of complexity, where an individual or a social group is more concerned to conserve its socioeconomic and cultural resources than its natural resources, because it sees its natural resources as only one of a number of possible economic options. If the natural resources fail, the larger society provides other opportunities for livelihood. On the other hand, if the socio-cultural system should fail, or the individual's place in it be lost, the natural resources may no longer be sufficient. Desertification has become particularly dangerous since forms of organization and technical planning methods and also the potential for implementing projects have reached a stage where the physical components have become insignificant in comparison with economic criteria. (Barth 1977, p. 59)

Economic criteria are social. They involve trading off the interests of one sector of a population against those of another. Where the trade-off is left to be decided by supply and demand, moral problems invariably arise. But generally political considerations interfere anyway. both with supply and demand and with moral issues.

Even within the ecosystem there is a moral problem. Where an ecologist is studying an ecosystem without a human component, or where his research interests allow him to ignore the role in the ecosystem of other members of his own species, he implicitly determines relative values for the various species in his study. For example, in an open steppe ecosystem the survival interests of grasses and fortes, shrubs, herbivores and predators are obviously in conflict. The ecologist stands outside the system but bases his research design implicitly on certain inter-related assumptions such as

1) the system should not run down; and
2) the number of species should not decrease.

However objective his research design, the ecologist is led by his assumptions to discriminate in favour of the survival of the system. The survival of the system is, of course, in the long-term best interests of the collectivity

of species. It is not, however, in the best interests of all individuals, some of whom will fall prey to predators. A reduction in the number of predators would, therefore, be in the best interests of at least some of the herbivores and a reduction in the number of herbivores would be in the best interests of many of the plants, and possibly also of the species of flora - irrespective of the stability of the system. If a gazelle or a shrub could produce a study of the same ecosystem we might expect their results to differ from those of the ecologist inasmuch as they would, as a matter of course, be based on different assumptions. These different sets of assumptions may be represented as scientifically more or less objective. However, insofar as they relate to the conflicting interests of different creatures which see right and wrong in terms of those interests, they are moral assumptions; and the conflict between them is resolved politically through the respective difference in power of the populations in question. These considerations are irrelevant, even laughable- until the human component is introduced. The application of these considerations to the case of each social group involved in any ecological problem - the approach advocated here will be referred to from now on as "the socio-centric approach," since it is based on essentially social (rather than purely ecological) assumptions.

This reduction of the relationship between the ecologist and his subject matter to questions of morals and politics may seem exaggerated, but it serves to focus attention on the moral and political aspects of the problems that develop between scientists and local populations in the treatment of declining ecosystems, especially in the case of desertification. When the ecologist includes a human population in the system he is studying, his recommendations for treatment and management are likely to conflict with the perceptions of the local population. These conflicts can be presented as differences between scientific understanding and uneducated superstition and self-interest; but it may be more realistic - and more practical, politically- to minimize the difference between science and lore. It then can be seen as the difference between perceptions based on an interest in the long-term survival of a total ecosystem and its usefulness to human populations on the one hand, and perceptions based on less long-term interests in individual economic and group cultural survival on the other.

The formulation of the problem of comprehending human use systems and ecosystems within a single theoretical framework and the development of the concept of the ecological transition are promising steps towards a theoretical bridge between the social and the natural sciences. In relation to problems of resource management and human welfare, they are particularly important at this stage because they are directly relevant to the initial problem of determining criteria of relevance. Desertification is serious because it constitutes the decline not just of productivity, but of productivity for the support of human wellbeing. On the one hand it means loss of resources at a time when demand is increasing; on the other it means human suffering due to lowered standards of living, nutrition and public health, the disintegration of social and cultural systems, and consequent social unrest. These human social and cultural conditions, the biopsychic state of each collectivity of individuals, provide the only logical yardstick for the human evaluation of the implications of ecological change.

The greatest problem, however, is to determine which human social interests have priority in the establishment of the yardstick. The establishment of a non-human factor (for example, soils) might disguise the assumption that a particular set of human social interests - those that valued the present state of soil distribution over those that were happy to see it changed - had priority. The significance of the following example is such that it is quoted in full:

Inj the Valley of Nochixtlan in southern Mexico. . . many. . . side slopes are ravaged by active gullies which remove the surface wholesale and leave the slopes bare of vegetation, fields or houses. Since the Spanish Conquest, an average depth of 5m has been stripped from the entire surface area, producing one of the highest rates of erosion recorded in the world. Set between the forested uplands and the agricultural valley floor, the area seems a wasteland which only drastic soil conservation measures could reverse.

Government experts share this view and have instituted conservation measures including the construction of low earth ridges to slow down soil movement. Few scientifically trained experts would disagree with their general perception of the bellying as a problem but the view from inside the valley is different. Gullies are seen not as a hazard but as a resource. By directing the flow of the eroded material, Mixtec farmers can annually feed their fields with fertile soil and can, with greater effort, extend their agricultural land by building new fields over a few years.

Over the past 1000 years, Mixtec cultivators have managed to use gully erosion to double the width of the main valley floors from about 1.5 km to 3 km; and to infill the narrow tributary valley floors with flights of terraces several kilometres long. Judicious use of gullying has enabled them to convert poor hilltop fields into rich alluvial farmland below, using the gullies to transport the soil. Thus before large-scale gullying began, the agricultural productivity of the valley area was less than it is today.

The difference between the "outside expert" view and the inside Mixtec one rests on the farmers' greater experience and knowledge of the local situation. Their experience of the highly fertile and erodible local deposits, and their familiarity with the technical and social bases of controlling soil movement, are too particular to the valley of Nochixtlan to be readily translated to other areas. Thus the concept "gullies are good" is not part of the outside expert's portfolio. Nor could he be expected to know that intermarriage between the hill-top and valley-bottom communities enables families to "move with their soil" down-valley.

The valley of Nochixtlan is an unusual case; usually different groups agree that soil erosion is a problem but disagree about how to solve it. This example is intended, however, to illustrate the importance of understanding local perceptions of the environment in the context of local resource use and social structure. But this is only the first, important step. In the example of Nochixtlan - as almost every where both perceptions of the environment are valid, within their own contexts. For the farmers in Nochixtlan, gullies are an important agricultural resource. For the government authorities concerned with the area as a whole, gullies are also a problem - not for those farms whose owners remain, but for the farms abandoned by their urban-migrating owners and no longer receiving replenishment and protection from the gullies. Thus, the national "problem" is that of urban migration and rural depopulation, which is the higher-order one, and which is outside the scope of agricultural authorities and local communities. (Whyte 1977, pp. 11-13; italics supplied)

This difference of perception is the central problem in ecological studies involving people. The word "problem" is used in this context because there is conflict. The conflict is not natural, or cultural, but social: it derives not from physical or biological factors, or even from difference of opinion or ideology; it is social because it is generated by differences in interests that derive from people's place in society in relation to the natural resources they depend on. It therefore demands the attention of the social scientist who can assess it in the light of comparative analyses of other social contexts of perception. The above example juxtaposes the different perceptions of a local population and an outside expert. But human use systems generally include a number of social groups with competing interests, and are functionally inter-related with other human use systems.

In this respect, of course, they resemble ecosystems. The ecologist claims to differentiate between different species in ecosystemic processes in terms of an objective hierarchy of trophic levels and general evolutionary and ecological theory. When the same methods are transferred to the study of the relations between the various social groups that compose a human use system, the claim of objectivity cannot be allowed to stand. The investigator's social and political allegiances are much more obviously and closely involved. The principle of natural selection is not only inadequate but morally untenable. Any problem of ecological management or rehabilitation that involves human populations begs obvious moral and political questions. These questions are reminiscent of Veblen's Theory of the Leisure Class (1899) which illuminated the moral and political dimension of economic problems in the American society of the time, and incidentally has recently been used to excellent effect to explain the recent conflict between Consolidated Edison (which supplies electrical power to greater New York), the population of Manhattan, and the wealthy residents who overlook the Hudson River at Storm King Mountain close to the proposed site of a nuclear power station (Tucker 1977).

Any theory of ecological change that involves change in relationships between people and environment, whether in desertification or industrial pollution, must be socio-centric in such a way that it relates ecosystems to human use systems and differentiates between the interests of populations and social and cultural groupings which are immediately involved in the process and populations that are only indirectly involved; it must represent fully the interests of each social group affected. Further, it must make this representation without assigning or implying fault. It must be a "no-fault" theory.

The argument for a socio-centric theory, however, must face up squarely to the fact that desertification was "discovered" by non-social scientists. The cry was taken up by specialists in the applied natural sciences and in

development. They diagnosed it, described it, and have made a number of attempts at defining it. The only role seen for the social scientist was to persuade the local people to stop doing what the specialist determined they should not do, and instead to do what the specialist determined they should do. But if we are to make the next step beyond the human use system. we must include in our reports and diagnoses more attention to the dynamics of the social factor in ecological processes.

From system to organization

The social factor is essentially a question of organization. The study of variation in the organization of social life beyond Western society has been the special province of anthropologists. In fact, attention to temporal and spatial variation in human life remains in one form or another the underlying characteristic of anthropological work. Practitioners differ among themselves partly in what types or aspects of variation they wish to explain, but most importantly in what assumptions they base their explanation on. Their approach is varied, from outright mentalist to uncompromising behaviourist; their assumptions can mostly be characterized in terms of functionalism or structuralism, but the intellectual tradition is held together by the implications of shared faith in the research method of "participant observation" and the aim of interpreting social and cultural phenomena in terms of particular people's own social and cultural universes. This combination of method and aims, whether mentalist or behaviourist in assumption, has generated a cross-cultural view of human life that is unique among the academic disciplines.

In the case of ecological degradation in dry lands the anthropologist is trained to focus on the social and cultural definition of a situation, the differentiation of interest groups within it, and the values and perceptions of individuals as they make the decisions which are the only components of the causality of desertification that are susceptible of preventative, as distinct from curative, treatment. But the anthropologist, as much as any other scientist, also has the problem of scientific objectivity. His analysis is just as vulnerable to unconscious bias in favour of one or another interest group. At an international symposium on "Anthropology and Desertification" held at the Central Arid Zone Research Institute in Jodhpur, December. 1978 (See Spooner and Mann 1979, 1982), it was suggested that the best way to avoid such unconscious assumptions might be to pursue anthropological analyses explicitly in terms of the perceivable range of public policy options in any given context, since public policy is the most practical guide to a socio-centric approach. Since there can be no absolute yardstick, public policy (which, though relative, is the most politically acceptable declaration of purpose a society can produce) provides the best guide at the level of government.

Desertification is a new subject for anthropologists. But it is one for which their specialties are particularly important, both because of the type of societies on which (for historical reasons) they have mostly concentrated their energies, and because of their theoretical preoccupations: they are concerned with the organization of behaviour and of thought, which they study comparatively, through its variation. By comparing the different forms and permutations of organization in human life, both synchronically and diachronically, they can discriminate and interrelate the range of different socio-centric approaches and perspectives in relation to a given issue.

In general, it is important to spell out as many examples as possible of different socio-centric approaches, but it is also important to note different levels of discussion. For example, in the various arenas of the anti-desertification debate two levels of discussion have become evident. They are both inherent in the political process and cannot be kept entirely separate: the campaign to organize for the purpose of conserving resources can never entirely free itself from the campaign to reorganize the distribution of resources. The consequent dialectic between overt discussion of how to organize in the existing system and the underlying theme of how to reorganize the system is particularly noticeable in two other arenas. Most obviously, it arises in the relations between populations which are at risk or suffering from Desertification and the planners and implementers of management programmes designed to combat desertification. Perhaps most significantly, it characterizes the relations between natural scientists concerned with the viability of physical and biological systems and social scientists concerned with the viability of social and cultural systems.

To give an example from the arena of implementation: management programmes designed by range scientists to address the long-term ecological balance in the relationship between animals and carrying capacity in the arid and semi-arid rangelands of the world are based on values and perceptions different from those of pastoralists. Coming from a different cultural environment and a different social class and trained in different land use systems, the ecologists are led to define the context of the problem differently and to place a different emphasis in the aims that they pursue in relation to it. The ecologist is primarily concerned with the long-term productivity of the resource; the pastoralist is concerned with survival - first in the short term and then in the long term. Survival for the pastoralist means not only his own personal survival but also his social and cultural survival, which involves the survival also of his socio-cultural group, which invariably depends upon the productivity of the herds. In the interaction between the ecologist and the pastoralist over the implementation of a management programme that would redress the balance in the ecological system of which the pastoral population is a component, the explicit bargaining concerns specific elements of the management programme; implicitly the values of the ecologist are pitted against the values of the pastoralist - in a conflict that will be resolved eventually in the larger political process.

The United Nations Conference on Desertification provides a further example. The slogan of the conference was: "Desertification can be halted and ravaged land reclaimed in terms of what is known now. All that remains is the political will and determination to do it" (UNCOD 1977b, p. 61).

The delegates to the Conference were asked to accept existing knowledge as adequate for the immediate purpose and to focus their discussions on the problem of organizing its successful application. They were told that their task lay in the organization of programmes and resources in order to make possible (in the words of the Plan of Action approved by the Conference) "the immediate adaptation and application of existing knowledge." Like all UN conferences, therefore, UNCOD was political in the sense that it was concerned primarily with organization.

Organization on this scale transcends the province of ecology, where Desertification is diagnosed. Answers to problems of ecological management beg questions of management of the political economy. As often happens in such international forums, discussions were conducted on two levels. While ostensibly the delegates were discussing means and guidelines for the organization of programmes in which they would cooperate to mobilize resources and combat desertification, many were using the discussions to bargain about relations between the parties to the Conference. Most delegates saw that solutions to Desertification lay in the mobilization of resources, but many also blamed the incentives for exploitation of people and resources that they considered to be inherent in the present world economic order, and saw the solution in the reorganization of that order. While all the delegates accepted the ecological explanations of Desertification and the technical solutions that were preferred, many were more concerned with causation at another level: that of the economic and political conditions that generate land-use decisions and access to resources. The organizers of the Conference pursued the strategy designed to keep deliberations at the former level, but the "political will and determination" that they sought to stimulate were more abundant at the latter level, though more difficult to harness (See Spooner 1979, Spooner and Mann 1982).

In general, therefore, we are concerned here with organization on different levels - social, cultural and ecosystemic. As long ago as 1930 Koehler wrote that "physics is becoming the study of organization. . . in this way. . . it will converge with biology and psychology" (1930, p. 5). The rise of general systems theory and cybernetics accelerated this process. Ecologists, such as Odum (See above, p. 22), have sought to put everything together in terms of levels of organization. But the progress in our understanding of organization and its significance has overtaken our ability to deal with the moral problems it poses. Appreciation of the organizational dimension is no substitute for the investigation of cause and effect. Although the focus on organization, microcosmic or macrocosmic, facilitates dialogue across professional boundaries and interrelation of professional fields, it does not necessarily help when we need to modify a particular situation, and it does not automatically provide a basis for action. In order to decide how to proceed towards the solution of a practical (as distinct from a theoretical) problem, we are obliged (if not for moral reasons, then for the political reasons which in the end upstage moral considerations) to go into cause and effect, responsibility and interest, of groups and of individuals. The admission of the human factor into questions of ecology and development logically forces these apparently nonscientific, non-objective factors on our attention.

In any particular case of ecological degradation a primary cause or causes might be sought in national policy or in the international economic and political order. Secondary causes derive from related local changes, such as the spread of new technologies. The direct cause in a particular location might be overgrazing or opportunistic dry farming. The symptom which will be picked up by a direct monitoring system is an increase in soil erosion or decline in primary productivity. The significant economic effect will be loss of production. Finally, the human effects will be evident in cultural stress and social change.

It is important to note that the socio-centric approach provides a framework for comprehending the whole length of this chain of causation. A socio-centric approach to ecological change must integrate not only all these levels of cause and effect, but all the relevant disciplinary sets of data. But integration alone is not sufficient. integration also tends to give priority to one or more factors over others, and therefore implicitly begins to explain. This explanatory function must be made explicit in the form of theory. The theory must take account of the centrality of human activity. Since the dynamics of human activity are complex and vary according to experience, age, sex, and other criteria for the division of labour, and between closely and distantly inter-related social groups of which more than one is likely to be implicated in any natural process, the theory must discriminate between different relevant social situations and interrelate them.

There can be no absolute criterion for determining among the different socio-centric explanations that would fit the interests of the various social groups. Deciding among them can only be a question of political process and public policy. A socio-centric theory of ecological change, therefore, must be designed to inform public policy.

There is more to be learned from the literature of anthropology about the organization of people in relation to technology and resources. The correlation of social structure and production technology does not mean that any given social structure can only accommodate one particular technology. A little thought will produce examples to demonstrate that "human communities typically rearrange themselves to accomplish various tasks" (Gearing 1958, p. 1149). The concept "structural pose" was formulated to facilitate explanation of these rearrangements in a study of American Indians:

The notion of structural pose. . . draws attention to the well-established fact that the social structure of a human community is not a single set of roles and organized groups, but is rather a series of several sets of roles and groups which appear and disappear according to the tasks at hand. The notion of structural pose elevates that known fact to a position of central importance in structural analysis. In every human community, a series of social structures come and go recurrently. A Cherokee village in 1750, faced with a community task such as holding a village council, divided that work and coordinated it by arranging all villagers into one social structure. Whenever the white flag was raised over a village council house to call the council, a young male villager assumed with little or no reflection a defined set of relations with every other villager. At the moment before, perhaps, his most engrossing relations had been with other men of his own age; now his mind's eye shifted to the old men of the village. Before, perhaps, his fellow clansmen had been dispersed and variously occupied with diverse interests; now they all came to sit together and were engrossed with him in a common task and were a corporate group among other like groups. Faced with another task, such as negotiating with an alien power, the community rearranged all villagers into still a different structure of roles and organized groups. (Gearing 1958)

In more complex societies some structural poses are achieved through formal or administrative forms of organization (See Wallace 1971). It is worth noting that since they are designed for specific production objectives, administrative forms of organization, such as those represented in the organizational charts of large firms, depend for their success on the insulation of each individual in his position on the chart from the influences of the external social structure in which his everyday life is embedded. In order to maintain this insulation and also to obviate the hindering effects of personal relationships that develop between persons who work together, it is common for management to move individuals frequently to different positions on the chart where they will carry out similar but different functions, "interfacing" with different people, and for the chart to be continually modified with the aim of maintaining and improving efficiency. This concept of insulation gives some insight into the most serious difficulties that have been experienced in attempts to develop the use of new agricultural technologies in the context of traditional social forms. Research reports on the formation of water-user associations to solve environmental problems caused by inefficient irrigation in Pakistan show how this concept might be applied (See Merrey 1982, and below, chapter 3).

There is a sense, therefore, in which any community has not one social structure, but several. Each member of a community has a repertoire of different roles which change according to his activity. As situations change, he moves from one role to another. According to the task that is being performed, the people involved each play a particular role from their repertoire. As a group, they develop a structural pose or special form of organization for each community activity. A community of transhumant pastoralists takes on one pose at a wedding, characterized by the fact that the wedding symbolises a new alliance in a series of which each one modifies the constellation of interest groups that generate the political process. The same community would take on a different structural pose at a meeting for making decisions or resolving differences about the timing of a pastoral migration, where a different type of expertise would come into play and different persons would be influential. If the same community turned from transhumant grazing to perennial irrigation, it would develop a series of new structural poses, but this time without the benefit of directly relevant expertise. The introduction of water-user associations in Pakistan should be seen as an attempt both to provide the expertise and to develop a special form of organization. The organizational problem is how to design the water-user association in such a way as to maintain a balance between cultural and ecological variables - whether or not the system is in equilibrium. The results of such a perturbation are difficult to predict. In the Sahel in the early 1970s, in combination with other factors including prolonged drought, the result was a major disaster. The social forms, which in earlier periods had periodically experienced and survived drought by dint of the flexibility in man-resource relations that they afforded, no longer worked after a decade of development combined with relatively good rainfall had encouraged reliance on newly engineered water sources with consequent increase in herd size and in population, and decrease in flexibility.

In the latter type, the populations were actually constituted on newly created resource systems and left to work out for themselves, from the assorted cultural baggage they had brought with them, not only an appropriate social structure but a suitable agricultural technology. The organization of agriculture on the basis of newly engineered perennial irrigation on a large scale in the Punjab (now Pakistan) in the 19th century serves well as an example. We should not be surprised if the result was ecologically inefficient. The structure of social relations and of man-land relations, with which the population embarked on the application of the new technology, did not facilitate the necessary types of cooperation, leadership and conservation.

These two cases are developed in detail in chapter 3 in order to demonstrate how any production technology is embedded, for good or ill, in a social structure. A change in technology is likely, therefore, to require a change in the social structure. Where a new technology is introduced from outside, the indigenous social structure does not necessarily adapt to its requirements. Further, the manner of introduction of the new technology, and the choice of individuals through whom it is communicated, may cause perturbation in the social system. Any such perturbation is likely to have repercussions on standards of resource management and human welfare.

Finally, in this regard some of the problems of bridging the gap between traditional social forms and modified or modern production systems might be alleviated if more attention were paid to the relationship between individual and group interests. What does the individual perceive as incentives or disincentives? An important first step in this direction is the recognition that individual interests may legitimately conflict with those of the continuity of the group (which is the locus of interaction between cultural norms and everyday behaviour), as for example in the type of situation characterized as a tragedy of the commons (Cf. Martin 1982b); that it is unrealistic to expect altruism; and that it is reasonable to anticipate a similar degree of villainy in all societies and therefore also to plan for it by designing administrative forms of organization that will contain it.

Attention to the need for incentives, especially in the form of real participation in significant decisions (provision for which should be built into any technological or administrative innovation) will help avoid the two extreme forms of organizational problems characterized by enforcement from above, and the too-rigid structuring of participation. These problems are responsible for most failures in planned social change. Appropriate incentives will also facilitate change in the symbolic or cultural dimension, in tune with changes in social form and population-environment relations.

Many (though not all) cases of desertification involve traditional food-producing technologies where the mode of operation of these technologies has changed in recent decades and is no longer explicable except by reference to a larger economic system that includes both the production and demand of an industrial society. Economic and

political domination of traditional by industrial forms of society is often the crux of the problem of motivation on the part of the population that is immediately responsible for desertification. When people are faced with aridity in fluctuating degrees they may be expected to develop particular individual behavioural characteristics, and social and cultural adaptations, which will be a function of their total social universe. When they are faced with increased aridity or sudden worsening of production and living conditions, they may be expected to experience stress to the extent that their social and cultural system breaks down and they re-adapt "in the context of a set of imperatives imposed on them by the larger social system" (Bennett 1976, italics added).

The argument so far

We are now able to see that the problem of the human factor in applied ecology may be broken down into two problematic relationships and the variation in those relationships, specifically:

1) the lack of congruence between ecosystems, human use systems and other universes of study (Different types of human activity. and different types of scientific problem require treatment within different boundaries of study);

2) the relationship between individual behaviour and processes at the group or population level - whether social, cultural or intra-species;

3) the continuous change in the relationship between human activities and natural processes, and between human use systems, communication networks and ecosystems. While not unilinear, this change has displayed a general evolutionary tendency for human systems and networks to expand and become less dependent on particular ecosystems (which is the process that Bennett, 1976, has brought to our attention in the ecological transition).

The formulation of strategies to explain and manage the human factor in these conditions faces three problems.

a) The first is a moral problem: Each social group (if not in some cases each individual) has potentially different legitimate interests. Applied ecology, although it must be a factor in deciding among these interests, is not sophisticated or reliable enough to be the only factor. Information must be organized and interpreted according to a socio-centric standard or yardstick (that is, from a socially or culturally derived point of view);

b) The second is a theoretical problem: What constitutes explanation of any given process, even within a socio-centric framework?

c) The third is the contextual problem: What is the basis of the changing relationship between ecology and society that is continuously changing the ground rules for both explanation and morality?

The second of these problems is discussed further in chapter 4; the first and third can only be solved by continued compromise between differing and changing perceptions. Such compromise is the essence of any national political process, as well as everyday life on more intimate social levels. It is complicated by the fact that the ecologist's case is commonly reinforced by the central authority, which shares his assumptions, or minimally pays lip service to them. However, that authority derives from the political process and, ultimately therefore. from the various interest groups which achieve participation in the political process. The population involved in a process of desertification may or may not have a voice in the relevant political process.

In any case, to the degree to which the populations using the resources that are at risk of desertification are represented in the larger political process, they are divided into different interest groups. Any proposal to manage the threatened resources according to the scientist's values unavoidably benefits some interest groups at the expense of others. Since the final arbiter is the political process and relative power (in which the ecologist's claim

to possess absolute values is an important but not a determining factor), it may not in the long term be a realistic ecological management policy to allow the terms of reference for the solution of desertification problems to be defined exclusively according to those supposedly absolute values. In the long term, the only acceptable yardstick which will change with changing conditions is public policy, which already implicitly fulfills that function.

The concept of the ecological transition helps us to place the human factor in historical context and the discrimination of different levels and types of social organization helps place it in structural context. Bearing in mind the important analytical distinction between ecosystems and human use systems and other universes of human activity, we can now think in terms of the totality, for which the term "socio-natural system" has been suggested (Bennett 1976, pp. 109-112). None of these concepts solves either the moral problem or the problem of complexity, but public policy provides an acceptable and practical handrail to guide us from one research task to another. It changes with the political process and serves as a guide to social relevance, acceptability and priority. Most importantly, it integrates our three dimensions from a socio-centric point of view and it serves as a basis for action.

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Some avenues of compromise

After arguing at such length for the essential differences between the natural and the social sciences as factors inhibiting satisfactory treatment of the human factor, it would be encouraging to be able also to wind up this chapter by pointing to some theoretical convergence. There have, in fact, been several developments that deserve some discussion here, some promising, some not so promising.

First, a recent movement that has led to some cooperation between social and natural scientists is socio-biology (See, for example, Chagnon and Irons 1979). Although sociobiology is in fact unlikely to produce work immediately relevant to the concerns of this essay, it is useful to note it here, because it provides an example of the problems that any cooperation bridging the social and natural sciences is bound to face. The root of these problems lies in the fact that claims to objectivity are less likely to be questioned and are more easily upheld in the natural sciences than the social sciences, because in the natural sciences the investigator is further removed from his subject matter and there is less likely to be any suspicion of conflict of interest.

Socio-biology is based on the natural-science premise that human behaviour is to at least some degree determined by the interaction of genetic and environmental factors, and that these factors continue to interact in complex determining ways throughout the life of each individual. It does not, therefore, deny the basic social science premise that it should be possible to change behaviour by changing the social or cultural environment. However, since it minimally involves the idea that biological variation can cause cultural variation, it threatens the autonomy of social theory. For, it suggests not only that sociological analysis might be dependent on biological analysis, but that biological analysis might illuminate moral issues. Hence the common accusation that biological analyses of social and cultural data encourage reactionary politics (Chagnon and Irons 1979, p. XV). When people study non-human subject matter, they can avoid moral positions (or ignore moral implications). When they study people, the moral implications surface, and recent social and political history has made them more obvious.

Implicit confusion between investigation of the nature of the world and pursuit of the best way of living has been a perennial problem in philosophy. Both the natural and the social sciences have suffered from it. Their cooperation in a single theoretical framework is made so difficult because they suffer from it in different degrees; and while the natural sciences can ignore the confusion, the social sciences cannot, because of the kinship between investigator and investigated. At the theoretical level socio-biology also fails to provide an integrative mechanism because it depends exclusively on the correct application of an essentially natural-science concept: natural selection. Any integrating mechanism must be equally appropriate to each dimension of reality. In this case, natural selection cannot be allowed to upstage the moral issues.

Secondly, transactionalism, an important theoretical development in social science which has been pursued in anthropology in the 1960s and 1970s primarily by Barth (1966, 1967 and 1972), offers some hope. As yet it has undergone little empirical testing (See Kapferer 1976). Its promise lies in the fact that it is generally accepted even by the more isolationist social scientists, and it is based on a model of society that should seem familiar and acceptable to natural scientists because it focuses on individual transactions and chains of transactions (in a manner reminiscent of, but not borrowed from, the biologists' focus on natural selection) between actors with a repertoire of statuses in an environment that is both cultural (or historical) and ecological. Despite some rather strong criticism, mainly on the familiar grounds that it ignores power and values (Paine 1974), and the effects of group membership {Cohen 1974, p. 40), Barth's and others' development of transactionalism could provide a basis for cooperation between the natural and the social sciences at the theoretical level (parallel to public policy at the practical level) because it de-fuses the difficult (for the nonanthropologist) problem of cultural relativism

and moral values by focusing on the minimal units of social process in a way similar to game theory, and by equating culture with environment.

Thirdly, reference has already been made to the argument that different types of process - biological,

social, cultural - interact over time in ways that can be usefully summarised and interpreted as co-adaptation. The particular argument cited was based on a historical view of the ecology of pastoralism (developed in Nyerges 1982). it depends on the extension of concepts from one discipline to another, not directly (in the ways we castigated above) but by analogy. A more detailed example of the potential of this analogical method can be developed from a consideration of a recent characterization of arid ecosystems by Noy-Meir (1973, 1974).

Particular attention has been given during the 1970s to the modelling of varieties of ecosystems for the purpose of developing more reliable principles for land-use management within them. Modelling alone does not provide a mechanism for the integration of social with natural theory, but it could produce results that would be helpful in this enterprise. For example, the exercise leads Noy-Meir to formulate the following three basic attributes of arid ecosystems:

- precipitation is so low that water is the dominant controlling factor for biological purposes;
- precipitation is highly variable through the year and occurs in infrequent and discrete events; and
- variation in precipitation has a large random (unpredictable) component.

There fore, he concludes, it is useful to define desert ecosystems as "water-controiled ecosystems with infrequent, discrete and largely unpredictable water inputs" (1973, p. 26).

Working from these basic attributes he lists seven features of arid ecosystems for the purpose of modelling:

- the dominant influence of the space-time distribution and dynamics of water (sometimes in conjunction with heat and salt) on energy flows and species adaptations,
- the occurrence in discrete pulses of the major input and many biological activities,
- the importance of reserve forms and stages and of the transfers between them and active pulses,
- the large random component in environmental variation and the special adaptations to uncertainty,
- the marked effects of spatial heterogeneity in the environment on total energy, water, and nutrient flows and on survival of many species,
- the opportunistic food habits of many animals, leading to complex food webs,
- the very different "stabilities" of the arid ecosystem at different time scales and in relation to different types of "disturbance." (1974, pp. 209-210, emphasis added).

As a result of these conditions, the plant ecology of arid environments (and by extension also the animal ecology and the human ecology) is characterized by the struggle with aridity- up to the point where success brings a degree of population density such that the main problem becomes competition for water.

These principles are sufficient to explain the following general characteristics of arid ecosystems:

> "In mature arid shrub communities, root systems may occupy most of the area where canopy is only 3 to 5 per cent. Evidence for within-species competition is the regular spatial pattern sometimes observed in desert shrub populations; in other cases, evidence may be obscured by habitat micro-heterogeneity. Mortality due to competition for water has been indicated in desert annuals populations.
>
> Competitive inhibition of shrub seedlings by mature shrubs, to a distance 5 times the canopy radius, has been demonstrated. . . Many phenomena in the distribution of species and communities in arid and semiarid zones can be explained only by assuming strong between-species competition for water. The yield of forage grasses and fortes in semiarid rangelands is inversely related to density of woody perennials.

> Some desert shrubs produce allelopathic substances that inhibit germination and growth of other species. . . Salinisation of the soil surface by salt accumulating and excreting halophytes, with consequent inhibition of nonhalophytes, is apparently common.
>
> Positive effects of shrubs and trees on other plants, as expressed in spatial association, are also often observed in deserts. The microenvironmental modifications involved are partly atmospheric (reduction of radiation, temperature, wind, and evaporativity) and partly edaphic (increased organic and nutrient contents, accumulation of windblown sand and silt). Other mechanisms are concentrations of windblown seeds and protection from grazing. (Noy-Meir 1973, p. 47)

The critical factors affecting production and survival in deserts are those which determine water supply and the efficiency of conversion from water to energy. For example, the rate of herbivore consumption is controlled by the availability of water, and the water balance (which is further conditioned by the heat and salt balance) of the animal. The input of water into the system is stochastic. The system is driven by irregular pulses of short duration. Typically, there are ten to fifty rainy days per year in three to fifteen rain events or clusters of rainy days, of which probably no more than five or six (sometimes only one) are large enough to affect the biotic components of the system. The periods between these events receive a zero input. The system as a whole operates in an irregular pulse-reserve pattern. No cycles have been demonstrated. The main adaptational problem, therefore, lies in the adjustment of response to exogenous environmental signals so as to optimise growth and survival. All animals have the added problem of heat and salt balance coupled with water balance in the typically extreme desert temperatures, but they also have the advantage of mobility which allows them to exploit spatial variation. In some special cases, the use of available water is inhibited by special conditions, such as very cold winters in Central Asia.

There are two basic adaptations to these conditions:

> — slow quiet exploitation of secure niches with defenses against aridity and competition, and behavioural restriction of transpiration to periods of low evaporation, as in the case of shrubs with a secure underground water source and no competition; and
>
> — bursts of energy in response to precipitation, putting all effort into getting as large a share as possible followed by return to dormancy; unrestricted, rapid inefficient transpiration is an optimum strategy for annuals in competition with each other. Some plants known as C4 plants because carbon dioxide is first assimilated into a four-carbon carbohydrate - have developed a more water efficient way of taking in carbon dioxide in photosynthesis.

In either case, the major problem for each species lies in how to survive the dry period between (exogenous) rain events. Survival is generally by means of reserves. The nature of these reserves constitutes the most significant field for research.

In this characterization of arid ecosystems based on the current state of knowledge there is an abundance of ideas for the formulation of hypotheses about the organization of human activity in arid areas, and such hypotheses can be used without imposing an ecosystemic framework on human activity. For example, in human populations in arid lands a similar pulse-reserve pattern may be seen. Most traditional systems of food production are adapted in this way. Nomadic pastoralism is a good example. It is opportunistic. Strategies of herding and husbandry are designed to make the most of the pulses and accumulate enough stock to make it through the reserve periods (See Sandford 1982). Most pastoral development schemes, on the other hand, are based on estimation of continuous sustainable production levels. That is, they focus on the reserve period.

The only way to evade the constraints of the pulsereserve pattern involves some form of manipulation of the water input on a massive scale such as modern irrigation engineering. Such engineering requires investment beyond the means of the small local populations. Exogenous investment in the economy of arid lands is analogous to stochastic rain inputs in the ecology.

This reasoning by analogy leads to insights into the relationships between populations and their environment that do not prejudice social theory. Analogy serves as an integration mechanism at the level of the formulation of hypotheses.

A final example derives from the characteristic assessment of arid ecosystems as fragile. Analogy leads to the hypothesis that social systems in arid lands are similarly fragile. Examples can easily be found to corroborate this hypothesis, though not to prove it. But it is worth considering that deficiencies in human wellbeing generally are as much or more due to the fragility of cultural and social systems than of ecosystems. A solution to a desertification problem is not a solution unless it comprehends the problem of human welfare in a socionatural universe. A technical solution - in the sense of a method to de-salinise land or to develop a new soil base is not a solution. It is simply an engineering technique.

For similar reasons desertification is sometimes wrongly diagnosed. If a community living on the edge of moving sand migrates, it does not necessarily mean that the sand is evidence of their abuse of their resources. It can mean that the socio-economic system of which they form a part has changed in such a way that they choose to move. When they move, they cease to maintain their investment in the productivity of the area and the sand does then encroach, so lending credence to the wrong explanation. (An example from northeastern Iran is given in Spooner et a/. 1980.)

This review of the various trends of reorientation in human ecology over the last decade has led us to a consideration of the value of analogy as a means of interaction and communication between orientations. Analogy is an element in all inductive investigation (Stebbing 1933, p. 256), and is therefore well suited to serve as a bridge between what are different, largely deductive disciplinary investigations. By drawing attention to similarity in certain respects, it suggests new hypotheses which can be valuable and lead to genuine dialogue, so long as the attendant dissimilarities are also noted and the hypotheses are tested according to independent criteria. In the following chapter we attempt to construct a threedimensional picture of two ecological problem situations in historical perspective, using public policy as a value base and this type of analogical reasoning as a heuristic tool.

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3. Illustratory

The international development effort so far has been based on the injection of investment and the transfer of technology. The people affected, whether as target populations or by contingent processes, have (on the basis of the assumption that they conform with our ideals of rationality) been expected to adapt themselves both as individuals and as groups to the resulting new conditions, and to develop new ways of relating to each other- new structural forms that would facilitate the optimum operation of the new technology. Within this paradigm, few specific projects and fewer large situations can be claimed as unqualified successes. Local populations rarely respond as expected. A common reason has been that their motivation is embedded in an organizational or structural form that was an integral part of the traditional production system and is not adapted to or appropriate for the new technology. When they run into ecological problems as a result, they often suffer disapprobation as well as deprivation.

Analyses of ecological problems deriving from development projects have suggested that deterioration of the environment can have negative consequences for society and individuals alike; but although the economic costs of environmental problems can be estimated fairly reliably in terms of lost production, the social, cultural and psychological costs are difficult to quantify usefully. These non-economic costs generate rearrangements in the distribution of populations and in social groupings which affect future living standards and production levels in ways we cannot predict. The need to view the totality of behaviour, thought and ecology in a perspective geared to the priorities of ecological viability and public policy presents insurmountable problems.

The long-term relationship between trends in living standards and environmental perception, between perception and responsibility for resources, and between responsibility and ecological impact is difficult to demonstrate conclusively. In South-west Asia, however, the fact that the interrelation of ecological and social problems can be viewed in the perspective of ten or more millennia of human residence and food production makes such a study somewhat more promising than elsewhere. This chapter treats examples of two types of land use that have been historically important in Southwest Asia, with the limited aim of illustrating some of the points argued in chapter 2.

Desertification and development in South-West Asia: A historical perspective

Roughly one third of the land surface of the earth is generally classified as dry and is estimated to contain fourteen percent of the world's population (UNCOD 1977a: p. 6-10). The productivity of dry lands is generally low, but their extent is so vast that their total production is nevertheless significant. Most of the territory of Southwest Asia is composed of such dry lands. The dry lands of South-west Asia in Iran, Afghanistan, Pakistan and North-west India are particularly important in the development context, because as a whole they are more densely settled than other dry regions and because their present population has inherited environmental problems caused by the longest history of human settlement and food production. But apart from the large sums spent on engineering the control and delivery of river flow, dry lands generally - and particularly in South-west Asia have received relatively little investment so far. However, they have great potential for development, if only the

environmental problems can be solved. Therefore solution of the environmental problems of development in Southwest Asia is not only of direct economic significance for some one hundred and fifty million people, but is likely to contain important lessons for other dryland regions.

Historically the most significant types of land use and food production in South-west Asia have been irrigated agriculture, which requires substantial investment and is an intensive form of land use; and pastoralism, which requires relatively little investment and is extensive. In some semi-arid areas they have been combined with dry farming. Although these basic types are technologically very different, they have been closely interrelated, socially and economically, for thousands of years. Most human communities, especially in dry lands, have made use of two or more technologies; or if they have specialised to the effective exclusion of a second technology they have interacted economically with other communities which exploited different resources. The development effort, however, with its pronounced emphasis on technology, has not only tended to separate the treatment of technology (traditional or modern) from consideration of its social context, but has also neglected the interdependence of different technologies from the point of view of local labour and domestic economies.

Historical evidence shows some significant declines in production from time to time during the last five thousand years, but the causes (which appear in most cases to have involved a combination of both human and natural factors) have not been reconstructed convincingly. The Harappan civilisation of the Indus valley, for example, which must have been dependent on irrigation, fades from the archaeological record in the middle of the second millennium BC. The Mesopotamian systems (in presentday Iraq and southwest Iran) have gone through several cycles of growth and decline. The decline of irrigated agriculture in the Helmand delta (now on the border of Iran and Afghanistan) coincided with political decline in the tenth century A.D. Most systems of this type in developing countries have been in decline during the period of European expansion and in some cases much longer.

The value of a historical perspective is that it exemplifies the range of possible adaptations to a particular set of natural conditions, and their ecological and other consequences. The historical development of irrigation in the Indus valley and of pastoralism on the Iranian plateau is discussed in appropriate places below, but before getting into that more detailed discussion it will be useful first to summarize here the history of these forms of land use in South-west Asia.

Environmental problems in development generally derive not from basic technologies such as types of irrigation or grazing, but from the scale of the productive activity in relation to the resource. Before the first attempt to develop irrigation in the Punjab in the middle of the last century, irrigation (which probably developed in its most primitive form not long after the domestication of plants and animals, some ten thousand years ago elsewhere in Southwest Asia) had already served as the basis of vast agricultural projects, and had had environmental effects which reduced productivity seriously. The best known example is from Mesopotamia (see Jakobsen and Adams 1958 and Oates and Oates 1976). This was probably the largest ancient (preindustrial) system. Like smaller systems on the Helmand (now Afghanistan-lran), the Indus (now Pakistan) and the Oxus (now the Soviet Republics of Turkmenistan and Uzbekistan in Central Asia), and in other parts of the world, it was generally restricted to flood plains and was seasonal, depending on the annual flooding of the river.

Perennial riverine irrigation, which requires storage and gradual release of the water through the period of minimum flow, is largely the introduction of the industrial age. Such irrigation has allowed major increases in area under cultivation and intensification of cropping but it also magnifies the adverse effects of irrigation: soil salinity and waterlogging develop faster and some of the effects are more difficult to reverse. Perennial irrigation as a means of increasing agricultural productivity is an invaluable technological advance, but indiscriminate application can lead in the long run to reduction in productivity through adverse environmental change. In order to maintain productivity in the long term labour, water flow, and cultivation must be coordinated with some precision.

The oldest form of river flow irrigation in the Punjab (known as sailaba or flood-water irrigation) simply uses overflow within active flood plains. This simple technology has been economically important since the eighth century AD, when the Arabs distinguished irrigated from nonirrigated land for tax purposes. It did not require

largescale organization of labour and it was ecologically viable, since it flushed the land, preventing accumulation of salts and maintaining fertility by the deposit of silt.

The next stage was the construction of inundation canals. These canals greatly extended the area of cultivation at the expense of a significant increase in labour requirements. But they were vulnerable to floods and were less viable ecologically, since they included no provision for drainage and so caused the accumulation rather than flushing of salts and raised the water table. But it is important to note that these canals for the first time required large-scale organization of labour, and of water distribution. However, this requirement was not yet beyond the capabilities of the local communities. So far the technology did not require organization on a scale larger than the immediate community.

The next change was from inundation to perennial irrigation. It was a quantum change, the spread of which marks the contrast between the ancient and modern periods. The modern period is characterised by much higher investment and involvement in a much larger economic universe. Where the ancient system had already grown beyond the capability of private enterprise and depended on government investment, the modern system depends on investment which is beyond the means of many national economies and is supported by various forms of international investment. The enormous increase in investment needed for this increase in productivity would not have been feasible except for a similar increase in the potential market. The market was originally provided by the investors - the British. It carried the Punjab through the ecological transition in more senses than one. Both the physical map and the society of the Indus Valley was gradually and irreversibly transformed. The process makes one of the most interesting stories in human ecological history. There is room here for only a brief mention of some of the most significant landmarks (For a longer review see Michel 1967).

In the middle of the nineteenth century the first modern perennial irrigation engineering project was begun in one of the interfluves of the Punjab, in what is now Pakistan. Despite setbacks, the programme gradually grew to incorporate all the Punjab plains and was extended into Sind. The enormous increase in the injection of water into these basically desert areas soon began to cause environmental problems. But no one felt any need to attend to them: it was simpler and more profitable for the investors to extend the programme onto new land than to repair damaged land.

The Indus valley irrigation system soon became by any standards the largest integrated irrigation system in the world. it has been growing for 130 years, and although now divided between India and Pakistan it is still being extended in both countries (though now as two separate systems), and still has room for growth. But in the wake of its expansion, serious environmental problems appeared. By the middle of this century these problems were causing real anxiety. Correction of them has become the major task of development. Beginning in the 1950s, development planning focused on increasing output in the Punjab by alleviating the environmental problems that had arisen during the colonial period as a result of the application of industrial technology to irrigation. But the planning was typical of the period: it was single-mindedly techno-centric. It was based on the assumption that such ecological problems could be solved by technology, and therefore paid little or no attention to their social or cultural dimensions.

Although the history of pastoralism in South-west Asia appears totally different from that of irrigation, there are interesting comparisons to be made. The two forms of land use represent opposite extremes in terms of the density of population they support and the level of investment they require in arid areas, but they are equally dependent - though in different ways - on exogenous political and economic factors.

Perennial irrigated agriculture is the most intensive form of land use and its development demands high investment and offers high returns. The necessary investment, which is generally beyond the means of the individual cultivator, or even the cultivating community, is carried out at the will of an urban-based financing institution. Really large-scale irrigation engineering systems, both before and after the Industrial Revolution, have been government programmes. Hence the perennial debate, worked out in classic form in Oriental Despotism (Wittfogel 1957), concerning the intimacy of the relationship between forms of irrigation engineering and forms of government. (Unfortunately this early attempt to treat technology as a problem of organization had no impact on the development effort, presumably because it did not deal in sufficient detail with technology as understood in the applied sciences.) In this way large scale irrigation engineering, because it requires substantial

capital investment, invariably brings the cultivator into close, though not necessarily happy, relations with a broader economic universe and with a bureaucracy, and might therefore be taken as the classic development situation.

Traditional pastoralism, on the other hand, requires minimal capital, and perhaps the major problem in pastoral development has been the integration of traditional forms of pastoralism into national economies. There is an important cultural aspect to this problem which has characteristically received less attention than the technological and economic aspects. It can be seen in the growing credibility gap between planners and pastoralists which leads to cultural discrimination and accusations of irrationality. The situation is complicated by the fact that many pastoral populations, especially in South-west Asia, are in origin overflows from settled agricultural populations, and generally pastoralists do not depend on other sectors of the population for investment. In any case, when the cities could not control the nomads, the nomads raided the cities, and the impact of this historical relationship is still evident in the general antipathy between governments, which want to control and administrate, and traditional pastoralists, who want to be free of external control.

Ecological history is of great importance for any assessment of traditional pastoralism. But it is extremely difficult to reconstruct it in sufficiently reliable detail. Very little is known of the history of the vegetation on which pastoralism has depended over recent millennia, let alone since the earliest times. However, in South-west Asia there is reason to believe that it is likely to have fluctuated as much in indirect response to investment in agriculture as in direct response to the quality of the vegetation and the climate. In recent decades the condition of pastoralism has been similar to that of irrigation, in that grazing lands appear to be in a state of ecological decline. In the case of pastoralism, population growth and external economic and political factors, such as change in the terms of trade, have often led to patent imbalance between animals and vegetation.

The resulting ecological change and damage is less sensational than that caused by the enormous investment in irrigation, but whereas only a few million hectares are at risk from irrigation, literally hundreds of millions of hectares are judged to be at risk from pastoralism. A major part, therefore, of the efforts to develop or modernize pastoralism (apart from arguments about the viability of traditional forms, especially nomadism, in the modern world), as with irrigation, has been devoted to counteracting what are assumed to be the adverse ecological effects of the history of that technology. The challenge of pastoral development was recognized somewhat earlier than with irrigation to be a problem of organization, but it was concluded that pastoralism should therefore be reorganized along lines similar to its recent evolution in the West, especially in the American West and in Australia.

Since modern irrigation engineering was developed *in situ* beginning outside the West in India (though by a colonial power) over a hundred years ago - its ecology has also been studied *in situ*, and is generally well understood. On the other hand, however well the ecology of modern (ie Western) pastoralism in the West may be understood, that understanding may be inadequate when applied elsewhere in the world where not only the history of the vegetation but the history of co-adaptation between sociocultural and natural factors is different. The questions that must be answered in regard to pastoral development are both ecological and social. They include the history of the vegetation in relation to particular pastoral technologies, as well as the social constraints and incentives that keep people in or push people out of a pastoral adaptation. Unlike irrigation, which is a new technology demanding new forms of organization, pastoralism already exists embedded within its own social forms. In order to make the most of existing systems, it is necessary to investigate in detail the adaptive relationships between vegetation, animals, and productive strategies of the pastoral population. This investigation has scarcely begun; what has been done so far, however, suggests that modification of the present situation solely on the basis of Western experience could be as damaging to long-term human interests in natural resources as a policy of noninterference, since such modification breaks down existing systems and dissipates both the human resource and the heritage of local environmental knowledge.

The most significant difference between the irrigation problem and the pastoral problem is that the former is a technology essentially industrial and exotic, so that the need for a new organizational structure to implement it is obvious. The latter is *traditional*. How the productivity of traditional forms of pastoralism might be increased and their environmental problems alleviated is a question that has not been sufficiently investigated. (A rare example in South-west Asia is in Martin 1982b.) Instead, as a result of the cultural difference between pastoralist

and planner, it has been assumed that exotic forms of management of range vegetation or animals should replace traditional forms, despite the fact that the traditional forms were developed in conditions that were different in terms both of natural resources and of cultural perception and the market context. Nevertheless, both the irrigation and the pastoralism problems in South-west Asia pose problems of organization.

Some mention must also be made here of rainfed or dry farming since it has been an important historical complement of both irrigation and pastoralism. Although it is less important as a source of development problems, in South-west Asia the extension of dry farming onto unsuitable surfaces as an indirect result of development, or simply of modernization, has been doubly damaging, since it has led not only directly to soil erosion, but indirectly to overgrazing on poor ranges, in that it deprives pastoralists of their better pastures.

In terms of national economies and possibly also of overall economic significance, the most pressing environmental problems for the development of food production in Southwest Asia are those of waterlogging and salinity in the Indus Valley in Pakistan and of ecological decline on the rangelands of Iran and Afghanistan. Progress on the solution of these problems in these countries would constitute an important step toward the solution of many similar problems elsewhere. Work has been carried out on a large scale on purely technical solutions for both of these problems since the 1950s, but progress, though not insignificant, has lagged decidedly behind expectations. Although it has been proven in some cases that foreign experts are able to correct ecological problems and run similar systems without causing similar problems, the local populations continue to produce the same problems. The purely technical solutions must, therefore, for all their value be judged inadequate.

Finally, a comment is necessary on the scale of the following case studies of irrigation and pastoralism. The advantages or disadvantages of an exclusively technical solution would be best illustrated on the scale of a single project. Where ecosystems are the focus, a holistic study must be on the scale of the ecosystem. In the case of a human socio-economic focus, where the context of behaviour is the national economy, and the cultural, linguistic or religious grouping, a much larger scale is required - a larger universe of study. The process of decision-making is the core of the problem (Cf. Bennett 1976, Britan and Denich 1976), and it will not be understood unless the context of decision-making is allowed to determine the boundaries of the investigator's universe of study and of the planner's attention. If we are to break out of the succession of piecemeal, ad hoc, or middle-range solutions of local problems which, whether they work or not, prove nontransferable, it is necessary to change the scale of investigation and, at the same time, the orientation to the problem. Even the most productionoriented planner should logically focus on the human population because human labour is an essential resource, and not the most tractable, in any production system.

Therefore, any project - research or implementation should be designed and executed with due regard to the ecosystemic, the social, and the cultural context or universe of the problem. The fault in responses to the development challenge so far is that they have not been radical enough, in the sense that they have not gone to the human roots of the problem before designing the solution. If we are to make progress in development, it is necessary to leave the relatively safe and well-trodden methodological ground of small-scale technocentric and eco-centric case studies, and try something new, even though the theory for it may not yet have been fully worked out.

The remainder of this chapter reviews the two primary food producing technologies in South-west Asia with the aim of demonstrating the inseparability of investment and engineering from the constraints not only of ecological context but of social and cultural embeddedness. The purpose of the review is to show how the integration of all these factors might be achieved in development planning by systematically pursuing each of the three dimension secology, society, and culture - of the man-environment relationship.

I. Irrigation in South-West Asia

The case of the Punjab (Pakistan)

The environmental change caused by perennial irrigation in dry lands is spectacular. Both the change and the enormous investment it requires is more than justified by the similarly spectacular increase in productivity. In Pakistan today irrigation provides the major component of agricultural production, which is over a third of the country's Gross National Product. But the tremendous potential of the (natural) resource and the technology (on the drawing board) is frustrated in the application by ecology.

The growth of the ecological problem makes better sense when subjected to historical review. But the development record does not appear to have benefitted from such a review. The lessons to be learned from such a review become plainer when seen from the point of view of the individual farmer. The implications for policy are clear, but may be difficult to follow because we are so unused to integrating socio-cultural with economic, technological and ecological information.

Let us begin then with a brief description of the resource and the technology. The facts and figures are taken from Michel (1967) and the Water Management Technical Reports on Pakistan produced by the Consortium for International Development, especially Corey and Clima (1975), Eckert et al. (1975), Mirza (1975), and Radosevich and Kirkwood (1975). The cultural material is taken mainly from Merrey (1982).

The resource and the technology

The average total annual flow of the Indus River system in India and Pakistan is twice that of the Nile and 10 times that of the Colorado. It exceeds 170 billion cubic metres but, as is typical of dry lands, there is great seasonal variation in flow. Between November and February, the flow averages only one tenth of what is normal for the summer monsoon months. More direct rainfall adds an average 7.5 billion cubic metres to this resource each year and it is estimated that some 54 billion cubic metres can be taken annually from groundwater. Twenty four and a half billion of these are presently accessible, but because of greater salinity they must be diluted by mixing with river water before use. Generally the quality of river water is good, with 1 to 300 parts per million of dissolved solids. The whole system commands 15.5 million hectares in which soil quality varies from moderately fine and deep alluvial deposits in the flood plains to coarser deposits on the higher ground (bar) between the rivers. As is to be expected in dry lands, there is a general lack of organic material.

In 1947 the Partition of India and Pakistan caused a de facto division of this resource, which was formalized in the Indus Waters Treaty (1960) by which Pakistan received exclusive use of the Indus itself, plus the Jhelum and Chenab tributaries, leaving the Beas, Ravi and Sutlej (amounting to a little over twenty percent of the total average annual flow) to India.

The irrigation system that has been developed over the' last century and a quarter now diverts within Pakistan approximately 123 billion cubic metres of annual river flow and spreads it over 13.5 million hectares of cultivable land, of which nearly 9 million hectares can be irrigated throughout the year.

This controlled distribution is accomplished by means of 17 barrages and canal diversion works, 42 major canals, 6,000 kilometres of minor canals, 600 kilometres of link canals, and 78,000 watercourses. The total capacity is nearly 7,000 cubic metres per second, or 250,000 cubic feet per second (cusecs) as it is commonly measured. This flow is supplemented from 156,000 tube wells which raise 24.5 billion cubic metres from the subsurface water table. The overall pattern of flow is from one of the major rivers to major and minor canals through outlets (moghas) to watercourses (khals) to farmers'fields. What is not consumed as it passes through the system is either returned to the rivers or disposed of in some other (often more costly) manner or accumulates, resulting in waterlogging and salinity. Since 1955 a large network of surface drains has been created as part of a programme for the solution of this problem.

The purpose of this technology is to control the spatial and temporal flow of all the available water over the greatest area of cultivable land in order to achieve maximum distribution and optimum quantity and speed of

flow. The speed must be slow enough to minimize erosion of the bed and banks of the canals. While the horizontal movement of the water within the system is controlled relatively efficiently, vertical movement out of the system has proved more difficult to manage. The system is vulnerable to seepage and evaporation. By spreading surface water over a much larger area or "command" than it would naturally cover between two points in a stream channel, and by causing it to spend more time in the commanded area than it would spend in the channel, any irrigation tends to increase the amount of recharge to the water table. Once the water has passed both below the root zone of the crops and below the level (approximately 3 metres in the sandy loams that predominate in the Punjab) from which capillary action can raise it to the root zone, it becomes valueless, unless it can be pumped out again.

Excessive recharge causes the water table to rise. If it rises to the level where it interferes with plant growth by waterlogging, or if capillary action combined with evaporation increases salt accumulation in the upper soil horizons or on the surface, productivity is reduced.

The interrelation of efficient control of water with crop requirements demands not only complex engineering but sophisticated organization of labour. Altogether this form of irrigation is at once the most large-scale, most investment-intensive, and most economically significant technology of food production in human history. Both as an economic or social and as an ecological or natural system, it is qualitatively different from what preceded it. It might be expected, therefore, that development would require complete reorganization of the human population that works it. In fact, however, there appears from the beginning to have been a conscious policy on the part of the developers not to interfere with local practice. Formal irrigation administration as it has evolved from the beginning reaches down to the level of the canals and their outlets only. Lower level officials report water flow, regulate distribution gates, and organize maintenance work. There are now also tube-well operators. But from the canal outlets onwards the farmer has always been left to his own devices. He has had to align, dig and maintain his own watercourse and develop a rotating water delivery or distribution system in cooperation with his neighbors, without the benefit of any outside assistance or advice. There is often only one outlet per village and no congruence of watercourse-sharing communities with other social or spatial groupings of the population. The development of this resource and of the technology to exploit it has not been complemented by attention to the human resource without which it cannot be exploited, let alone by a comprehensive plan to manage both the physical and the human resources as a means to improving the wellbeing of the society.

The ecological problem

The greatly increased level of productivity per hectare is not sustained. As a result, increase in gross sown area cannot keep pace with population growth. In fact, even by the time of Partition the Punjab had ceased to produce any substantial grain exports. Even though Pakistan inherited almost all the surplus-producing irrigated areas, the combination of population growth and ecological damage quickly - by the mid-1950s - made her a net importer of her major crop and food staple, wheat.

The principal problem arises from the loss of cultivable land through waterlogging and salinity as a result of seepage, poor maintenance of watercourses, and inefficient application of water to crops. About half of the total irrigated land is estimated to be affected to varying degrees. Until recently the process was counteracted only by bringing more land under cultivation. Paradoxically, a subsidiary but related problem caused by water loss through these same processes and through evaporation, is lack of water.

Before the development of the system, water-table depths over most of the area now irrigated were about 24 to 28 metres. Historical data indicate that the water table has risen an average of 15 to 35 centimetres per year since modern irrigation was introduced. Of the 123 billion cubic metres diverted annually, only about 71.5 billion cubic metres reach the heads of watercourses. it has been estimated that from 5 per cent to as much as 65 per cent per mile is lost in the watercourses. Altogether, less than 30 per cent of the water diverted from the rivers gets to the root zones of crops and is consumed. Further, a salinity of 1,000 parts per million is acceptable for virtually all crops, but groundwater of that quality which evaporates at a rate of half a metre per year, a typical rate where the water table is less than a metre deep, will in 20 years raise the salt content of the top metre of soil to about 1 per cent, which is too high for even the hardiest crops. Not only, therefore, are environmental problems causing loss of cultivable land, but the irrigation system is working at only 30 per cent efficiency, and

this inefficiency is responsible for the disastrous loss of both land and water. These processes are almost certainly exacerbated by inefficiencies in actual cultivation. But these inefficiencies are disguised, because of the administrative segregation of irrigation from agriculture, which is characteristic of the way bureaucratic systems evolve (Cf. Spooner 1982a & b). In the 1960s it was estimated that between 20,000 and 40,000 additional hectares were being affected each year and, in the worst districts, 40 to 50 per cent of the cultivated land was already severely damaged.

Unfortunately, there is no exact method of quantifying waterlogging and salinity damage. Actual conditions vary from season to season, and year to year, depending partly on the strength of the monsoon and partly on other factors such as spatial variation in rainfall, groundwater recharge, and evaporation. Actual crop damage varies according to the sensitivity of the particular plant. Surface salinity has been compared to skin rash appearing in blotches which vary continually in intensity and extent.

Finally, it is possible that the ecological problem is caused by inefficient practice of the technology. Perhaps highlytrained farmers would be able to apply it without allowing excessive recharge to the water table. In this case the fault lies entirely in the neglect of the human component in the planning process. On the other hand, any such possibility remains to be proven. Perhaps the technology is deficient, and the fault lies entirely with the engineers and investors! The likelihood is, of course, that there are inadequacies in the technology and inefficiencies in the application, as well as incongruencies between the requirements of the technology and the perceptions of the farmers. But we do not know. Our knowledge is still almost exclusively technological and ecological. And what we do know about the people who use the technology has not been systematically related to their use of the technology. We tend habitually to keep our knowledge of resources and technology categorically separate from our knowledge of the way people behave and think.

The history of the problem

Before the middle of the 19th century, irrigation was confined to parts of the flood plains and was mostly seasonal. Pastoralism was the major form of land use, but was supplemented here and there by dry farming. Water was drawn during the summer when the rivers rose above the levels of canal inlets, and was used to irrigate lands which would not have received water by natural flooding. Such canals were, however, uncontrolled and did not allow exploitation of low river flows. Only relatively narrow strips of land along the rivers could be irrigated. The supply channels were inefficient: they depended on uncertain river flows and tended to silt up. There were also dangerous breaches during the flood season. In spite of these shortcomings, inundation canals constituted an important advance in the technology of irrigation. The system was subsequently improved during the Mughal period, especially in the 17th century, to the extent that limited perennial irrigation was possible in parks and gardens.

The traditional systems were designed to spread the water over as large an area as possible during the period of maximum flow. Limited engineering works maintained a constant level of water suitable to the level of the land to be irrigated, "heading up" the flow of water and distributing it though a system of canals. The modern system, construction of which began in 1851 and has developed steadily ever since, is designed for continuous control.

The motivation of the colonial government in embarking on this vast and innovative engineering scheme is in itself instructive. Like more recent motivations for further development of it, and for the development of similar projects elsewhere (for example, in Iraq, Afghanistan, Egypt and Soviet Central Asia), it was at least as much political as economic. The desire to appear to have improved on the engineering of earlier regimes provided the general motivation, while the immediate need to ensure against the threat of famine and to settle the recently-disbanded Sikh levies, were the specific motives. The guiding principle was uncautious optimism rather than careful research and planning, despite the complete lack of relevant experience. In addition, the colonial administrators wanted to expand the area under irrigation and bring new lands into cultivation so that they could be settled and taxed. Ancillary motives included re-settlement and relief of crowded conditions elsewhere,. the creation of a granary which could supply the famine-prone areas of north central India and, later, especially in Sind, creation of new areas for cotton production. The optimism inherent in these motivations hindered clear perception of the environmental problems that soon developed.

It is important to note the role played by perception. For decades there seems to have been a general tendency to ignore or misinterpret what now (with the benefit of hindsight) appears to have been obvious contrary evidence about the success of the technology. For example, on the Western Jumna Canal of the Ganges Basin (where the development of irrigation had begun, in what is now India, with the provision of permanent headworks in 1836), waterlogging and salinity problems had already appeared by 1859. Between 1870 and 1880, the irrigation channels were re-aligned and natural drainages cleared, with results which were encouraging but did not lead to a general policy for dealing with what was already becoming a general problem. When the Lower Chenab Canal, which opened in 1892, had produced serious waterlogging by 1908, some maintained the cause lay not in irrigation but in the fact that the canal, road and railway embankment were interfering with surface run-off, or even that the Punjab was in a rainy cycle. Others maintained that a high water table was actually an advantage, because it facilitated the operation of hundreds of Persian wheels in shallow wells and produced some regeneration of water supplies by seepage during the dry season. A Waterlogging Enquiry Committee was finally established in 1925, but still there was more interest in extending the system onto new lands than in reclamation, despite the growing awareness that the cost of bringing water onto new lands was increasing, the new lands had much coarser soils and lower initial fertility, their seepage and evaporation rates were higher, and even the Indus Basin would eventually run out of new land to replace the old in any gravity-fed surface-water irrigation system.

Partly as a consequence of the non-ecological motives and the unrealistic perception of the situation that they engendered, the cropping pattern was dominated by wheat which was the staple grain, and cotton, the obvious cash crop, which both made it feasible to spread the water thinly. However, even these crops, which have low water requirements, received much less than the optimum, and although sugar cane, which requires more water, was allowed to a limited extent, rice cultivation which would tolerate higher accumulations of salt as well as using more water, was generally discouraged, at least until the water table had risen close to the surface.

It is clear that even apart from the neglect of the social dimension there was a significant degree of wrong-headedness in the history of irrigation planning in the Punjab, and it is not surprising that it should take considerable time and intellectual pain to rethink it.

The development record

Since the 1950s efforts have been made to reduce evaporation and seepage but only to the extent that the cost appeared economically justifiable in the context of the *perception* of the problem. Apart from the policy of spreading the water thin, which had always carried an economic rationale, canals were re-aligned in badly leaking places. Some canals were lined and some surface drains were reconstructed. These practices have been continued up to the present. They have included no social component, and have had little impact on the general problem.

The most promising technical attack on the problem was a type of comprehensive control strategy. However, although such a strategy was proposed as early as 1927, it was not approved until 1944 and not put into full operation until 1952. In an effort to both lower local water tables and provide additional supplies of irrigation water, 21,257 tubewells were sunk along badly seeping canals in two of the interfluves. Although this scheme (known as the Rasul Scheme) was not particularly successful, because most of the wells were too close to the canals and actually accelerated seepage, it did lead to a better understanding of the problem. It was followed by a second similar scheme in 1953 - 4, and a third in 1957- 8. Finally, when the Water and Power Development Authority (WAPDA) was established in 1958, it was specifically entrusted with "prevention of waterlogging and salinity and reclamation of waterlogged and saline lands." At last the problem had been officially recognized, but the diagnosis was exclusively technological.

WAPDA's Salinity Control and Reclamation Projects (SCARP) have steadily increased the number of tube wells ever since. The factor which differentiates these projects from their predecessors lies in the concentration of these tube wells in fields of from 1,500 to 3,000 units, each with three to four cusecs (85-110 litres per second) capacity, and each serving approximately 250 ha. The capacity and spacing of the wells is designed to allow full control of the drainage in each project area.

Combined with supplies from an even greater number of privately owned one-cusec wells, and the enhanced surface water supplies made possible by the newly constructed Mangla and Tarbela dams on the Jhelum and Indus Rivers, the amount of water available for irrigation in Pakistan is now estimated at over 100 million acre feet or 1,233,438 million cubic metres. Two-thirds of this supply is from the surface water storage and distribution system, and almost one fourth from the government-owned tube wells. The total supply represents a substantial improvement over the 68 million acre feet or 838,772 million cubic metres available in 1965 and thus enhances significantly the capability for efficient irrigation of crops and for leaching of salts from the top soil.

This increased amount of water spread on the surface, however, would serve only to increase the waterlogging and salinity damage to soils and crops - except that the massive concentration of high capacity tube wells offers the hope of *controlling* the level of the water table. But a further problem is the quality of the ground water. Wherever the ground water is of usable quality (up to roughly 2,000 parts per million of total dissolved solids, depending on the chemical composition of the salts), its use for crops should produce a net gain, and through consumption and evapo-transpiration result in a gradual lowering of the water table. In other areas, saline ground water must be mixed with surface water of good quality before being applied to crops. To accomplish this mixing, canal capacities in certain areas need to be enlarged. In some areas, the ground water has proved too saline even for blending and must, therefore, be exported, either by the rivers (which will cause problems downstream), or via new wasteways constructed for this purpose.

Although the technical problems of the SCARPs have been overcome, and the projects have caused a significant improvement in the situation, they are nevertheless still inadequate. For example, in SCARP no. 1, which began in 1962, the water table has declined to an average of two to three metres. below the surface, and about 45 per cent of the affected area was reclaimed in the first nine years. Subsequently, however, progress was rather slow - a development which has been attributed to the sodicity of the soils. Generally, yields have improved as a result of land drainage, reclamation of considerable areas, and increase of water supplies from tube wells, together with additional agricultural inputs, such as fertilizers. In one experimental project area the gross value of agricultural produce - both crops and livestock increased by a factor of 2.5, but deterioration in groundwater quality is causing adverse changes in chemical characteristics of the soils and decline in the yield of sensitive crops.

Pakistan's groundwater and reclamation programme represents an extremely complex and costly effort to offset the consequences of inefficient surface-water

irrigation. For the periods of Pakistan's third and fourth fiveyear plans (1965-1975), the total cost of government owned tube wells, canal remodelling and drainage works (not including surface water storage) was set at about US $1,100 million, or slightly more than the cost of the Tarbeia Dam which itself represents roughly half the total cost of the Indus Basin project. It was expected that the gains achieved in Pakistan's agricultural sector, which grew at a healthy rate of 3-4 per cent per annum between 1960 and the early 1970s (though most of the gain was due to nonfood crops), would eventually more than compensate for these investments. But it was understood that these gains would depend not only on increased surface water and ground water supplies, but on further input of fertilizers, improved seed varieties, insecticides, and pesticides, and improved techniques of irrigation and cultivation. Generally, it was recognized that although reclamation programmes must be continued, the best hope for future progress lay rather in prevention. It remained, however, to develop a clear strategy for prevention.

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The farmer's perspective

One of the background documents prepared for the United Nations Conference on Desertification was a UNESCO sponsored case study based on experience in the Mona Reclamation Experimental Project about 240 km northwest of Lahore in Pakistan. This case study, together with other reports from the Mona project, have provided some of the most specific information on the ecological problems of the Punjab and provide one of the clearest windows onto the social situation in which those problems are embedded.

It is not clear when irrigation was started in the project area but there is evidence of prosperity there at least as early as the 17th century. New canals were brought into the area in 1860, and the present form of controlled irrigation began in 1901. Part of the area received perennial irrigation from the lower Jhelum canal and is divided into regular squares to simplify planning. Another section of the area (commanded by a canal known as the Shahpur branch), which has only recently been incorporated into the lower Jhelum canal system, is not divided into squares. As a result, traditional and introduced systems of land tenure are mixed in an overal planned system.

The relation of people to land in the Mona Project Area is uneven. As many as 50 per cent of the land holders have units below the subsistence level. About one fifth of the cultivators are both owners and tenants, operating about 17 per cent of the total farm area. As many as 37 per cent of the cultivators are landless tenants, operating 40 per cent of the total farm area, although their rights are protected to a certain degree by a measure of land reform which was introduced in 1972. A further organizational problem is the fragmentation of holdings.

The gross area served by individual watercourses under the project varies in size from 150 to 600 ha, with an average of 280 ha. The water supply for these areas varies from one to three cusecs according to size. The watercourses branch off into field channels as they run through the farm land to deliver water to individual holdings. Usually all the watercourses are unlined: seepage can be minimised only by assiduous maintenance of the bed and sides of the channel in order to optimise the speed of flow and eliminate the possibility of puddling. The water is distributed turn-by-turn to each farmer starting from the head of the watercourse; the time of delivery is fixed in proportion to each farmer's area. The farmer diverts the water to his field by making a cut in the watercourse at the beginning of his land holding. When his stipulated time is over he closes the cut and allows the water to flow downstream for the next farmer.

The flow in the irrigation channel is dependent upon the flow in the rivers. There are times when acute shortage occurs and all irrigation channels cannot be supplied according to their full capacity. In such circumstances, canals are run with partial supplies and in rotation. The distribution system is designed for each outlet to draw proportional shares and for the water to be carried to the tail end of the channel. Shortages should thus be distributed proportionally throughout the system. and the increased control afforded by the new Mangla and Tarbela dams has anyway reduced the shortages. However, maintaining equality of access to water between farmers at the head and tail of a watercourse has always been one of the major logistical problems in the system.

For the individual farmer the most immediate logistical problem is water distribution. He receives his share of water according to a fixed cycle of distribution which may vary from a week to ten days. The length of time of his share in the cycle is directly proportional to the area of his land. Traditionally, the farmers on each watercourse worked out their own system of distribution (known as koccha warabandl) These traditional systems have the advantage of flexibility in that it is easy for individuals to enter into arrangements to swap shares in order to meet specific crop requirements outside the cycle. However, although their ability to make such arrangements is not restricted by the system, it may be restricted by their personal relations. In fact, their personal relations, deriving from the range of roles and statuses in the general social structure, may lead to a

degree of injustice in the operation of the system that renders it intolerable for the poorer and less influential parties to a particular watercourse.

In order to understand what actually happens in some not untypical - situations, it is necessary to appreciate some of the basic concepts and organizational features of the society. The primary social units in this area, which have provided the basis for interaction with the administration, are village communities. But within each village, the population is divided into kinship units known as biradari. The biradari is best glossed as a group of families related primarily through males who stand in a fraternal or filial relationship to each other. Since there is a strong preference for marriage with first cousins, marriages tend to reinforce the exclusiveness of existing kinship groupings rather than integrating unrelated groupings into a larger unit. The basic structure of the society, therefore, militates against cooperation on the level of the total number of parties to a particular watercourse, which in the typical case crosses biradari lines. This tendency towards exclusiveness in small biradari groupings of related families is exacerbated by vague distinctions of property rights and hereditary status related historically to the Indian caste system. Finally, the leaders of each biradari compete for izzat, which may be glossed as honour or "face." Izzat can be acquired only at someone else's expense. Punjabi village society is, therefore, structurally predisposed for competition and conflict between relatively small groups of families which are generally not large enough to constitute a watercourse community. The general structure of the society conflicts with the requirements of the technology.

How can such a situation come about? In this case, the answer is relatively clear, and provides an excellent illustration of the more general problem of technology in the larger sense - the organization of sets of tasks over time. The present population is of three different origins. The composition of the original population of the area before the development of the irrigation system appears to have been the main determining factor in the present structure. These people were semi-nomadic herders with subsidiary interests in dry farming and, perhaps, a little irrigation. From what is presently known of traditional modes of pastoralism in the area, it is immediately evident that the biradari structure correlates usefully with the requirements for cooperation, movement, and exploitation in this type of traditional pastoral system, because it provides for flexibility and cohesion on the scale of the camp group which must change frequently. As the development of irrigation led to increased carrying capacity and the labour requirements, settlers were brought in to supplement the population, mostly from similar backgrounds. A third component of the present population consists of refugees that have come into the area from India since Partition. These come from more diverse backgrounds, but appear not to have modified the structure of the society significantly. This interpretation not only explains the present problems in cooperative arrangements- it draws attention to the fact that sociocultural systems do not necessarily adapt to changing ecological or technological conditions as quickly or predictably as they are often assumed to.

The implications for policy

An important scientific and practical problem that has received far too little attention lies in the explanation of why such populations do adapt in some cases, and not in others. Although there is general recognition among farmers of the fact that more efficient cooperation would solve many problems, the most common response as might be expected, is individualistic: the farmer seeks ad hoc solutions to the problems as he perceives them. Adaptation at an individual level can produce a statistical or general trend, but such a trend is not equivalent to adaptation at the group or the more inclusive levels that are the business of planners.

For example, to counteract loss of productivity due to waterlogging, the farmer shifts from wheat to rice cultivation, even though wheat continues to be his dietary staple. He can do this because rice yields more calories per hectare, is salt tolerant, unaffected by waterlogging, and can be exported, and the farmer is able to buy wheat with the proceeds. Between 1949-50 and 1959-60 the area sown to rice in Pakistan increased over 30 per cent, from 0.93 to 1.21 million hectares; and the yield per hectare increased from 141 to 151 kg. Over the same period, the area sown to wheat increased only from 4.2 million hectares to 4.9, while the wheat yield per hectare actually fell from 154 to 133 kg. In these areas where salinity alone is the problem, the usual response has been to try to delay the process by sowing only one crop per year, or to spread the available irrigation water even more thinly over the saline land. Such a response ultimately increases the problem since the reduced application of water does not allow the leaching out of salts to a level below that from which capillary action operates. In consequence the salts return to the surface where they continue to accumulate until the land has to be abandoned.

These responses derive from the farmers' perception of the situation, and their perceptions are conditioned by their experience and by the way the social structure conditions their personal interests in relation to other people's.

Two ways to approach this problem are:

- to ascertain why the structure did not change with the change in land use (the various components of the population did, after all embrace the new technology), and apply this understanding to the design of inducements;

- to design an administrative form of organization that would harness the general structure in a structural pose that would facilitate the operation of the production system.

So far, the first approach has scarcely been tried; something akin to the second approach has had some interesting but so far inadequate results. For example, an administrative form of water distribution system (known as pakka warabandi) has been offered to replace the kaccha warabandi where the latter was not working equitably due to problems in social relations arising from the general structure of the society. In many cases it has been accepted; but it has an inherent disadvantage, compared to the kaccha system, in that it is inflexible and cannot be adapted to fit the changing requirements of individual crops. As a more inclusive and potentially flexible form of administrative organization, Water User Associations have been devised and tried out on an experimental basis. If they should prove successful, they may at the very least provide a better framework for communication between irrigation officials, engineers, and farmers. Land levelling, watercourse renovation, and reduction of the size of irrigation basins are examples of simple technological aids that can probably be pursued more successfully where a Water User Association facilitates communication and provides the farmer with the sense of participation, incentive and identity within the system that is presently lacking. But before any such association can be introduced formally, it will still be necessary to work out an adequate and suitable legal basis, which may be difficult in the present atmosphere of increasing Islamic consciousness in Pakistan, since Islamic law generally deprecates any form of organizational exclusiveness. If an Islamic legal basis could be worked out in such a way that the individual farmer perceives the incentive for participation, it may be possible to develop the Water User Association into a comprehensive solution to cover all the ad hoc technological measures illustrated above.

The concept of the Water User Association is important because for the first time it focuses attention on the organizational aspects of the problem. If it is to be successful, it must be given a formal legal basis that will constitute it as a special form of organization providing a degree of insulation against the influence of the general social structure, but building on focal concepts, providing incentive and protection for the weaker against the stronger participants.

A brief review of the organizational tasks that need to be comprehended within this administrative structure will complete this discussion of the major problems of ecology in development with respect to irrigation in South-west Asia. Any irrigation system logically breaks down into a number of sub-systems. The primary subsystem organizes investment of the money, equipment and labour that is required to build and maintain the system. The second organizes distribution among the population of shares in the system or rights of access to the resource. The third organizes spatial and temporal distribution of water-flow among the land parcels to be irrigated.

In an integrated system as large as that of the Indus River Basin, investment can only be organized by government. This investment problem cannot logically be totally divorced (as it generally has been) from the organization of the distribution of flow and of rights. However, below the level of the watercourse this organization requires a flexibility that must be provided by local arrangement. Lastly, the logistical problems of water control and delivery cannot be divorced from the requirements of the local systems of cultivation.

In order, therefore, that the existing technical knowledge for developing the resource without damage to the environment should be successfully applied, it is essential to integrate all these components of the total system administratively in such a way that the structure gives individual contributors to the system the sense of participation and the incentive and capability to make it work. The irrigation system in the Punjab is so large that

the organization of it is bound to be effectively independent of the organization of local community life and values. The crux of the problem, which is generally diagnosed as ecological and economic, lies in this social and organizational hiatus. The Water User Association is a possible first step towards an answer to this problem. But successful development of it will require far more attention both to the perceptions and interests of individual farmers, and the overall Islamic cultural framework, than has been given so far. Further steps will depend on the socio-political evolution of Pakistani society.

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Comparative situations

The Indus River system was the first to be developed for perennial irrigation on a large scale. The same technology has since been used to develop other comparable river systems in South-west Asia and the Middle East: the Nile in Egypt, the Tigris and Euphrates in Iraq, the Oxus and the smaller rivers of Soviet Central Asia, and most recently, the Helmand of Afghanistan. In each of these cases, there has been direct transfer of engineering skills and hydraulic theory, but apparently no transfer of ecological or social lessons learned concerning environmental problems or organization even though similar problems have recurred in each situation. This phenomenon can only be explained in terms of the perceptions of planners and the social structure in which they are embedded. The problem is illustrated in the cases of Iraq, Afghanistan and India.

Iraq

Iraq is heir to a longer history of more intensive premodern irrigation than Pakistan. Modern development of the system began in 1913, based on experience in the Indus Valley, and was stepped up in the 1950s (See Dougrameji and Clor, 1977; and Fernea, 1970).

Irrigation had been practiced in the lower Mesopotamian plain since the sixth millennium BC, but the present social situation derives from the influx of tribal populations from the south in the 18th century. From then until very recently the large work forces necessary to operate and maintain the system were commanded by local tribal leaders.

The Mesopotamian system selected arable land for wheat and barley cultivation close to the rivers, and dug ditches to the Tigris and Euphrates to irrigate them. Despite a twoyear cropping cycle which left the land fallow for two summers after each winter cultivation, productivity was quickly impaired by increasing salinity, and the people moved regularly to new areas. By 1950, approximately 60 per cent of Iraq's agricultural land was estimated to be seriously affected by salinity; 20-30 per cent had been abandoned and the rate of loss was estimated at 1 per cent per year.

Throughout the seven thousand year history of this system under various populations, salinity had been a recurrent problem, which the traditional technology could not counteract except by long-term fallowing or abandonment. But this historical record appears not to have influenced the perceptions of modern development planners.

In the Greater Mussayeb Project, which was initiated by the government in 1953 approximately 90 km south of Baghdad, a modern irrigation and drainage network was installed and the land was classified and distributed in lots to tribesmen, many of whom (as in the case of the Indus Valley) had no previous experience of agriculture, let alone irrigation. An important aim of the project, once again, was social and political: to break the old tribal system and generate a population of independent farmers. However, by 1964, only ten years later, rise in soil salinity and siltation in the canals had led to migration of some of the settlers and almost to disintegration of the system. Apart from some technical problems - for instance, the radial gates to the head regulator had been fitted in the wrong position so that the heavy silt-laden water of the river's bottom layers had been drawn into the canal system - social problems were largely responsible for the failure. No attention had been paid to fitting the technology to the existing social forms or generating a social unit that would be structurally adaptive to the requirements of the new technology.

A rehabilitation project was begun in 1965 and considerable success has been achieved since then in developing the technical aspects of the system and providing services to the population. However, it is not clear that the greatly-increased population (32,000 in 1976 compared to 15,000 in 1965 and an estimated 1,000 in 1953) has

generated more efficiency in agricultural practice. There is evidence to suggest that proximity to Baghdad (which enables technicians and administrators to make quick visits) and the consequent influence of urban values on local perceptions, may be largely responsible for some apparent success. No lessons from earlier experience have been applied to the problem of making earlier social problems more tractable in irrigation projects in more isolated areas.

Afghanistan

Afghanistan provides the most sensational example of the disappointment of technological promise by ecological process (See Michel 1959, 1972). The watershed of the Helmand River comprises 40 per cent of the country. River flow depends on winter and early spring rains and summer melt, and is even more variable than the Indus. Before the Kajakai Dam was completed in 1953, providing a reservoir of 1,495,000 acre feet or 1,844 million cubic metres. capacity, the lowest recorded maximum natural flow was 1,620 cusecs on the 22nd July 1953; and the highest was 50,100 cusecs on the 26-27th April 1949.

Major modern engineering was begun only in the late 1940s by an American firm, Morrison Knudson, and since the 1950s has been sponsored by US AID. The aims of the project were the familiar mix of economic and political: to control and store the river flow, bring virgin lands under cultivation, settle nomads, and contribute to the solution of national problems created by border disputes with Pakistan and Iran.

So long as the development of irrigation was confined to the flood plains and interfluves, no serious problems developed. But in the 1960s the project was extended onto virgin lands. The fact that these lands were characterized by shallow soils over impermeable conglomerates was not taken into consideration. As might be expected, environmental problems similar to those experienced in the Indus Valley and Iraq developed, but more quickly. No significant attempt was made to prevent them. The new farmers were not sensitive to methods of irrigation and cultivation that would avoid or slow the development of environmental problems, and in the allotment of settlers to the newly-created resources no attention was given to their socially-and culturally-derived perceptions. These lands are now worthless for the cultivation of wheat or cotton, and are probably most useful for what they can teach in the long term about the technology of reclamation.

India

Perhaps the most interesting comparison with Pakistan is to be made with north-western India, which is not only a continuation of the same geographical and cultural zone but includes a significant part of the same river basin and is heir to the same history of irrigation development. However, despite the general historical, geographical, and cultural similarities, the Indian experience has diverged somewhat from that of Pakistan. There are a number of reaasons for this divergence: particularly, the differences between the Indian and Pakistani shares of the system at Partition, and as agreed in the Indus Waters Treaty (1960); the difference in potential for development of the two shares, both in terms of water capacity and accessible arable lands; and the difference in numbers of technicians with relevant skills on the two sides. It is also important to note that optimum exploitation of the Indus River system is much more important to the national economy of Pakistan than to that of India. Nevertheless, India made a major effort to maximize the potential benefit from her share of the Indus Rivers (the Beas, Ravi, and Sutlej). Significantly, however, her strategy was to extend her irrigation system as far as possible through Haryana and into Rajasthan in order to produce the maximum social impact at the national level by spreading it as far as possible, rather than aiming for the greatest economic impact, either nationally or at the local level, by optimising the supply of water to the nearest arable land. This policy decision was supported by the commitment to line all canals to reduce two of the major problems discussed above in relation to Pakistan: water loss through seepage and the related long-term rise in the water table causing waterlogging.

The Report of the National Commission of Agriculture (India 1976) acknowledges that the water supply in many canals already is inadequate for crop needs and that "on many irrigation systems the present mode of utilization of water is wasteful. On (pre-existing) unlined canals in the alluvial tracts, only about two-fifths of water released at the canal head is utilised by crops; the rest is lost in transit and in the field" (ibid., vol. 5, p. 10). However, elsewhere (p. 76) it is stated that in Punjab, Haryana and Rajasthan, the state irrigation departments are "responsible for managing supplies right up to the field including distribution of water among the co-sharers on

each outlet" which suggests that bureaucratic management systems play a more significant role in local ecological processes on the Indian than the Pakistani side.

Still, in India, too, waterlogging and salinity are significant problems. In Punjab and Haryana alone, 800,000 hectares are estimated to be affected. The report considers the most important cause of land degradation to be "wanton misuse and interference" (ibid. p. 178), and emphasises the importance of solving the associated social problems. It underlines the social significance of the problem by continuing: "it is not by coincidence alone that by and large the poor occupy these lands" (pp. 178-179), though it does not spell out the implications for the abilities and prospects of the poor or for public policy.

What is particularly interesting in the comparison of the Indian with the Pakistani experience, as with the other examples, is that even in a case where the developing country is relatively well endowed with experts, most of them trained in India, the development strategy is the same. The underlying philosophy, in fact, derives from the same Western tradition and is equally technocentric, rather than socio-centric. The general tenor of the report of the Indian National Commission suggests a faith in enforcement as ultimately the only answer to the environmental problems arising from irrigation. The communication gap between the expert and planner on the one hand and farmer on the other is as great or even greater than in countries where the experts are imported from the West. The lesson to be learned from this observation is important: the sociological problems of environment and development derive from class and other political differences within developing countries (which may or may not be related to exogenous influences such as Western education) as well as from cultural differences between local farmers and foreign experts.

II. Pastoralism on the iranian plateau

The arid and semi-arid rangelands of the Iranian Plateau, in Afghanistan, Iran and Pakistan, are also spectacular. But the spectacle lies in their vastness in relation to the sparseness of the resource they have to offer, not (as in the case of the Punjab) in their productivity per hectare. In fact the resource is important probably as much for its vastness as for its productivity. However, its present and potentially increased pastoral productivity is significant for the national economies, and for economic, sociocultural, and political development in each of the countries of the area. Furthermore, national as well as larger interests demand both that the vast steppe, semidesert and desert spaces that separate cities and smaller settlements in the region be domesticated, and that their sparsely distributed, isolated populations be integrated into national life and given the same opportunities as their fellow countrymen in the cities. The question here is one not so much of the potential for transformation of the resource as of the difference between rational use and nonuse.

The resource and the technology

Unlike the irrigation resource, which exists only in a limited number of well-defined locations, the pastoral resource is an uninterrupted expanse. Some 120 million hectares (out of 165 million) in Iran, 55 million (out of 65 million) in Afghanistan, and an only slightly smaller proportion in Pakistan are loosely classified as rangeland. Most of this vast area lies on the Plateau and, without irrigation, cannot be used efficiently for any food-production system other than pastoralism. If its pastoral use can be efficiently developed, not only will national and regional food production be greatly increased, but an extremely important contribution will be made to the socio-economic and cultural integration of significant sectors of the population of each country.

These areas have been used for pastoralism to varying extents for up to ten millennia, but pastoralism is accused of depleting the natural vegetation cover and causing permanent reduction in primary productivity, leading, in extreme cases, to erosion, sand accumultion, and dust storms that also affect the quality of urban life. It is often forgotten that, unlike the case of irrigation where most of the population has been imported, the existing pastoral population in these areas is - like the soil and vegetation an irreplaceable local resource. Over generations

traditional pastoralists have built up an intimacy with the natural resource, and their use of it has modified it in such a way that they can now be said to be co-adapted. If this population were lost through migration, pastoral development would become considerably more difficult, because cultural values inhibit the movement of labour from the cities back out into rural areas, especially for shepherding. Both the natural and the human resource have suffered in recent decades from a negative attitude on the part of government, which has favoured farming to the detriment of pastoralism. This bias has led to the alienation of significant areas of rangeland for dry farming, even though pastoralism would be economically more productive in the long term.

The technology of traditional pastoralism has generally been assumed by development planners to be uncomplicated, and has received little attention. Anthropologists, who because of their choice of subject matter might have filled this gap, have in fact, with few exceptions, illuminated only the purely social and cultural aspects of the pastoral systems they have studied (See for example Barth 1961, Tapper 1979, and Equipe Ecologie et Anthropologie des Soci�t�s Pastorales 1979), without relating them to the problems and issues of ecology or, generally, even of development. Their work does, however, demonstrate that it is misleading to consider traditional pastoralism as a single form of land use. Our concept of pastoralism comprehends a wide range of variation of traditional practice. Within it we need to differentiate variation on a number of levels: natural conditions, availability and choice of suitable animal species and their ecology. market accessibility for their products, historical experience (especially of drought and war) and cultural values.

In order to make efficient use of natural grazing, which varies temporally and spatially according to season, topography and latitude, most forms of traditional pastoralism involve seasonal movement. The species of domesticated animal that pastoralism choose to herd (the usual range now is sheep, goats, and cattle; in most areas camels have largely disappeared) depends on natural conditions, on markets, and on cultural values. The decision to produce particular products depends on the same variables. Pastoralism - overall strategies, productivity, choice of products, and impact on the environment - should be evaluated in the light of these variables, which influence perception and attitudes to planned change. In the development record so far, however, recommendation of technologies or technological modifications has generally been based on considerations of alien experience of natural and economic variables, to the neglect of local experience and values. Although such recommendations may be valid for the natural resource if it were to be utilised by an alien population, they tend to be incompatible with the interests of the existing human resource - the people who run the risk of serious social, economic, and cultural disruption. This incompatibility would cause further decline in overall productivity.

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The case of Iran

In Iran no single renewable natural resource dominates development thinking as the Indus does in Pakistan, but pastoralism is an integral component of the Iranian scene. Both historically and today, wherever one goes in Iran pastoralists are never far away, and their significance is never simply economic. But as an occupation, pastoralism in Iran ranks lower than irrigation in Pakistan on the scale of values for the majority of the population; and the effects of this ranking are exacerbated by the history of relations between nomads and settled communities. This history left a heritage of fear (of the former by the latter) which, because of modern changes in the larger economic and political structure, has now degenerated into contempt and complicates the common perception of pastoralism.

The following account draws generally on the experience of the Turan Programme of ecological research (see below), most particularly on the work of Sandford (1977a), Iran (1976 and 1977), Martin (1982a, b) and personal field data.

The national context

Iran has a total population of about 34 million and a relatively high average per capita Gross National Product (equivalent in 1975 to US $1,650) which (taking into account changes in international oil prices) was growing at a rate of over 35 per cent in the mid 1970s. (Since 1978, information is either unavailable or less reliable.) Agriculture and pastoralism contribute relatively little to GNP, even though some 58 per cent of the population still live in rural areas. In contrast to the economy as a whole, agricultural output grew at only 3 - per cent per annum in the mid 1970s, and the output of the livestock sector at only 1-2 per cent. As a result of the slow growth of pastoral production in relation to population, national income, and consumption, there was a very rapid rise in the importation of livestock products. For example, recorded imports of meat and livestock for slaughter doubled in volume between 1970 and 1974, amounting to 65,000 tons of meatequivalent (about 12 per cent of total meat consumption) in 1974. Of course this phenomenon was largely a function of overall national development policy, but it is indicative of the general orientation towards pastoralism in Iranian society

In this connection it is important to note that most pastoralists in Iran are socially distinct from the greater part of the settled society. The structure of their social relations is different- most especially in the fact that patrilineal connections, stretching beyond the living generations, hold more significance for them, and tend to be used as explicit criteria for the composition and organization of communities and tasks. In view of the distinctiveness of these social forms, pastoral communities are generally referred to as tribes.

In Iranian history, the tribes have constituted an important political force, often presenting serious problems to the central government. In the modern period they were pacified, confederation by confederation, by Reza Shah in the 1920s. Despite considerable efforts by Government since then to frustrate nomadism (which generally reinforces tribal forms of organization) and, more recently, to encourage the introduction of Western patterns of pastoral production, and despite the decimating effects of two lengthy droughts (roughly 19581963 and 1968 1973), pastoralism in Iran is still largely traditional in technology. Traditional pastoral technology invariably entails seasonal transhumance for movement between summer and winter pastures. Many pastoralists are still nomadic, in that they move through their seasonal migrations with all their families and belongings.

The available statistics for pastoralism in Iran are probably not complete. but should be adequate to suggest a general order of magnitude. It is estimated that of a total ruminant population of around 53 million (of which probably close to 90 per cent are sheep and goats), 50-60 per cent are involved in major seasonal migratory (transhumant) movements between grazing areas. A recent estimate puts the number of nomadic pastoralists in Iran at 700,000. Some 25 per cent of all sheep and goats. and 18 per cent of the cattle, are thought to belong to

nomads and 13 per cent of the remainder belong to people who do not own land. Among farmers, small land-owners (with less than 10 hectares) control 42 per cent and 54 percent, respectively, of the national total of small ruminants and cattle. The average holding among settled pastoralists is 24 head (sheep and cattle). Holdings of more than 50 head make up only 32 per cent of non-nomadic small ruminants. Among non-nomads, ownership of cattle is fairly evenly distributed (90 per cent of all cattle being owned in herds of less than 11, and 55 per cent in herds of less than five). The ownership of sheep and goats by settled pastoralists is rather more concentrated: 32 per cent are owned in herds of more than 50. The degree of concentration of ownership of nomads' herds is not known, but is likely to be higher. Nomadic groups tend to be more specialised and there is evidence in some cases (for example, Barth 1961; see also Spooner 1973) of absolute minima below which herd size cannot drop without forcing the pastoralist to cut his losses, leave the pastoral sector, and move into the settled, non-pastoral sector of the economy.

These figures help demonstrate the degree to which pastoralism in rural Iran is both ever-present and embedded in the traditional society and economy, but unintegrated into the modern economy. Such situations tend to be the most resist ent both to development and to ecological management.

The ecological problem

The problem of pastoral development in Iran is formulated somewhat differently by politicians, economic planners, and ecologists, and differently again by the pastoralists themselves. These different formulations make excellent sense in relation to the particular interests of each.

Briefly, traditional pastoralism is perceived as economically unsatisfactory because of low productivity per animal and vulnerability to drought; socially unsatisfactory because of poor living conditions exacerbated by loss of population through migration to cities, by inadequate services, and by insufficient integration into national life; and ecologically unsatisfactory because it applies excessive pressure to the vegetation, leading to a cumulative adverse effect on the productivity and community structure of this renewable natural resource. It is important to note, however, that there is a dearth of reliable and systematic information to support these contentions, especially the last. In particular, the data which are generally used to support the ecological part of the diagnosis are the least reliable and systematic, but they typically receive the greatest emphasis in any discussion of the problems of pastoral development.

The history of the problem

Both historically and ecologically, pastoralism is in many ways the opposite of irrigated agriculture. In particular, it is an essentially extensive form of land use, and is not susceptible to the intensification of (natural) resource use and of investment characteristic of the industrial age. It does not demand large-scale investment, and the opportunities in it for development are very different. Its great importance from all points of view- especially that of development- lies in the fact that it can exploit almost all land, including vast arid and otherwise unproductive areas, and its products are of great nutritional significance. But perhaps no other traditional technology presents such difficult problems of economic integration and ecological viability. The discussion here is concerned less with specific projects than with the general causes of lack of success so far (especially in Iran, where because of the recent economic growth rate the problem has received most attention in South-west Asia), and with the relationship between social and environmental problems.

It is important to notice that pastoralism in South-west Asia presents somewhat different problems from other areas such as East Africa, most especially because it has a longer history (See Nyerges 1982). For both historical and ecological reasons, pastoralism in the Middle East generally has always stood in a close economic relationship with agriculture. Despite their economic inter-dependence, however, and the fact that there has been considerable interchange of population between them, relations between pastoralists and farmers have generally not been easy. This condition may be attributed to the difference in perception engendered by the differences in land use. Traditional forms of pastoralism have generated varying degrees of nomadism based on small social units with a high degree of structural flexibility. The nomad is concerned with detailed understanding of large expanses of natural vegetation. He is not interested in investing in the modification or improvement of the natural resources he exploits except. perhaps. to provide watering points (See Spooner. 1973). Agriculture, on

the other hand, ties individuals to specific resources - land and water- and requires them to cooperate in a more stable way in larger social units and invest in the improvement of specific resources.

The conflicting perceptions engendered by these differences in man-land relationships caused farmers to fear nomads in the past (when they often appeared as raiders or mercenaries), and now hamper economic planning since, insofar as the planners are local, they are invariably from agricultural stock and view nomadism accordingly. Therefore, the "credibility gap" between planners and pastoralists is greater than between planners and irrigation farmers. For these reasons also, pastoral development in South-west Asia presents enormous difficulties of planning and organization though perhaps from the point of view of technology and investment it may be simpler than in Africa. But if these difficulties could be resolved, the results would be of very great significance for the economic and social development of the whole area and beyond.

The development record

Once again, corrective measures so far have been directed towards the treatment of symptoms as perceived by specialists trained in a different cultural and economic environment. This perception has led to the introduction of a number of programmes of management and rehabilitation based on experience in other parts of the world, especially the American West: specifically, protection and reseeding of poor quality rangeland, demonstration projects, administrative measures to decrease and control stocking rates, extension services, animal health sevices, and the introduction of more productive breeds. Many of these projects have had some limited success, but the impact on the overall situation does not appear to be significant. Whether or not the experience of the American West, or of other similar areas of expert training, is appropriate to the natural conditions, it is highly inappropriate to the social and cultural conditions because it was based on the removal of the earlier populations (Cf. Baker 1976). The idea of removing existing populations in order to achieve a more productive and ecologically viable economy may sound preposterous, but it is by no means unheard of. It is worth emphasising that even if it appeared desirable from the point of view of the national economy, there may be alternatives which would be more feasible politically and more acceptable morally. Such alternatives will be found through social rather than ecological research.

The pastoralist's perspective

In order to provide better information for dealing with these and other problems of rural development in the more arid parts of Iran, the Department of the Environment (Tehran) embarked in 1975 on a comprehensive ecological research programme in an area known as Turan, some 500 kilometres east of Tehran (See Iran 1977, Sandford 1977a, Spooner et al. 1980, Spooner and Horne 1980 and Spooner and Mann 1982). The research area, which comprises some two million hectares on the northeastern edge of the central deserts, includes important winter grazing for transhumant flocks which produce meat for Tehran. The topography is diverse. Vast plains vary in altitude from 700 to 1,500 meters and mountain peaks rise to 2,200 m. The 200 mm isohyetose passes roughly through the middle. The whole is generally classified as steppic-subdesertic, and resembles other plateau areas of South-west Asia that are regularly subject to subfreezing winter temperatures. During the mid 1970s some 150,000 sheep and goats wintered in Turan from November to May. Of these, 25,000 belonged to the local settled population of about 2,000 and remained in the area through the summer. There was a close relationship of interdependence between the settled and the transhumant populations.

The structure of the local population and of its relationships with the larger society outside the desert areas is complex. Some 2,000 people are divided among 36 settlements. Traditionally several groups of pastoralists have used the area with different transhumant regimes. Some were entirely nomadic and tent-dwelling, moving into and through the area seasonally with their families and belongings. Others sent their flocks in for the winter with shepherds. All interacted economically with the local villagers in one way or another. This economic interaction was embedded in networks of personal relationships that spread beyond the boundaries of the small isolated social groups and (together with a shared moral system) provided the basis for the fluctuating degrees of security that obtained. These personal networks had a patrilineal bias, but matrilateral relationships were also important and women's labour was essential for a number of seasonal pastoral and agricultural tasks, especially milking, milk processing, and harvesting. The patrilineal bias was greater among the nomads, providing in genealogies

the stability of social forms that the villagers found in land ownership. There is a close relationship between the structure of the population and the division of labour.

Turan exports substantial quantities of livestock and livestock products, cotton, and tobacco. It imports paraffin, consumer durables, clothes, sugar. tea, small amounts of other foods, fertilizers, and feed barley. Although over 80 per cent of the animals that use the area belong to non-residents, some 30-40 per cent of the proceeds from the production of these animals returns to residents in the form of shepherds' wages; and a further small proportion may return as payment for feed barley grown or bought in the area.

The history of human activity in areas like these can be understood only as part of a larger area drawn to include urban and political centres that have provided markets and sources of investment and sought to control and exploit their hinterlands and secure the arterial routes that passed through them. The rise of the nation-state, with its more powerful political organization and technology, has modified this relationship. The desert outback is now much more consistently controlled from the city, rather than providing an economic and political balance to it. Further, new urban opportunities now cause additional pressure on the desert economy. Conventional recipes for pastoral development increase these pressures, without succeeding in their aims. They accelerate the process of disintegration of the desert economy.

The majority of the present population of Turan are probably happy to remain in the desert, so long as they do not feel they are missing out on attractive urban opportunities and services. On the other hand, city dwellers will not move to the desert except in return for large economic incentives, and even then will not have either the experience or the interest to exploit it well. If the present population leaves in pursuit of a better standard of living in the cities, it may be possible to reorganize pastoral production on the basis of imported labour. But a reconstituted population is likely to be less conservationist. Development is more likely to work ecologically if pursued through traditional forms with the existing population. Finally, the evidence suggests that ecological degradation is more a function of exogeny, originating from the urban market, the political power of the nation state, and the authority of urban values, than from the actual productive activities of the local populations (See Dennell 1982, Horne 1982 and Martin 1982b).

Information from preliminary surveys (made in 1971 at the height of the 1968-1973 drought) were interpreted to suggest that the natural resources of the area were deteriorating and the quality of life was falling further behind that of neighbouring, less-arid, and less-isolated areas. The vegetation cover was judged to be degraded and possibly still deteriorating in quality and quantity as the result of excessive exploitation by both settled and transhumant populations. The terms of trade between the pastoral, agricultural and industrial sectors in the national economy had changed during the decade to the extent that the transhumants were finding it difficult to hire shepherds, with the result that the traditional technology was being practiced less efficiently, but the overall pressure on the range had not diminished.

Compared to areas of traditional pastoralism in other parts of the world, Turan appears to have a reasonably healthy economy. Standards of housing, health and hygiene are relatively high. Wage rates for hired shepherds ran at Rials 120,000-200,000 in 1978 (approximately is $1,750-2,850 per annum, except that they often do not work throughout the year), plus food. Most shepherds also make some additional income from the village farming activities of their families. However, shepherding as an occupation carried a certain stigma, because it implied an arduous and uncomfortable life without modern facilities. Very tentative estimates of net income from one village in Turan, on the basis of an average livestock and land holding, suggest a possible family income in that village from livestock and cultivation averaging about US $450-625 per year. Such farm income could be supplemented by employment outside (for example, in carpet weaving) although opportunities were very few.

These figures compare well with other sectors. They may be even better, since this type of comparison can be misleading. It is necessary to bear in mind that in statistical comparisons of this kind the real value of housing, water supplies, and domestic fuel tends to be underestimated in published figures, which give an unduly poor impression of rural life. When figures are evaluated by comparison with per capita GNP, it must be remembered that GNP (which in this case would make these income figures look low) include much expenditure on government services and investment which is not applicable to family income and expenditures. A more meaningful comparison can be made by looking at figures for annual private expenditure per head. In 1973, such

expenditure amounted to about US $490 (Rials 34,000) per person for Iran as a whole, which is an aggregate of $800 (Rials 60,000) in the urban sector and of $210 (Rials 15,000) in the rural sector. On the basis of these figures and those given in the previous paragraph, and assuming that family size is about five persons in Turan, it appears that real incomes in Turan might be at least equal to, and perhaps considerably greater than, the figures for Iran as a whole. They may approach the level of the working class in urban areas, whose total consumption is only about 50-70 per cent of the average figure for all urban classes.

The major economic activity in Turan is the winter grazing of the transhumant flocks. Besides many that pass through Turan to areas further to the south-east, between three and four hundred of these flocks enter the area between mid-October and mid-November. The flocks average 400 head, consisting of approximately 80-90 per cent sheep and 10-20 per cent goats. They lamb in late February, take full advantage of the spring in Turan till midApril to mid-May, and then slowly follow the spring back up into the mountains to the west, taking some six weeks to cover 450-600 kilornetres. The animals are milked in the summer pastures only. Lambing percentages (live births) average 85 per cent of breeding females; of these, 85 per cent probably survive to weaning, and (in the case of males) to sale. Of the combined sheep and goat prelambing flock, some 70 per cent are breeding ewes, 3 per cent sires and 27 per cent replacement females. According to the general opinion, flock size and animal population throughout the area among the transhumants is constant from year to year. Variation occurs in the quality of the range and in the amount of barley consumed as supplementary feed. But the main problem today appears to be in the efficiency of labour, because of the growing competition with urban sources of employment.

Unlike the transhumants, the local residents' flocks vary widely in size. On average, breeding ewes form a lower proportion, since some holdings are primarily fattening rather than breeding and dairy operations. Lambing percentages in resident flocks appear slightly higher (possibly reflecting genetic as well as managerial differences). They also avoid the strain of long migration, but are forced to make do with inferior vegetation throughout the year. Mortality may be lower, as may feed costs, because of the availability of crop straws. The local owners rarely give their animals supplemental barley grain. The value of milk production per ewe or doe is higher than in the case of transhumants, reflecting both the fact that the animals are milked for a longer period, and the difference in breed. The proportion of the flock sold is slightly lower (since female animals on average are kept longer), but the unit value is higher, reflecting higher weights at sale. A local resident who gives roughly equal emphasis to pastoralism and agriculture in his economic strategies is likely to have a minimum holding of 30 animals, mainly goats, and to do somewhat better from them per animal than the larger owners.

The agricultural crops of the local population appear to be more important for supplying domestic needs than generating income, with the exception of cotton and tobacco (which are cultivated explicitly as cash crops) and surplus grains from dry farming in good years. The amount sown per year by individual families fluctuates according to several factors. The most important factor is the availability of water. Given water, the ability to command labour at the right time is probably the most critical factor and severely restricts the opportunities of some families. But there is always the possibility of adding several hundred dollars to the annual family income by these means. Once again, labour- the human resource - appears to be the crucial factor in this situation when viewed as a human use system, rather than as an ecosystem.

The implications for policy

The purpose of development is to increase economic productivity and ecological viability. Besides labour, to what extent do other factors inhibit expansion in Turan? Are the natural, the social, or the cultural predominant? Prices of livestock and livestock products, relative to the prices of other goods, were not unfavourable in comparison with prices elsewhere in the world. There may be some scope for reducing costs and margins in the marketing chain, but high costs or margins were not conspicuous.

Other factors were difficult to assess. Losses from livestock diseases did not appear to be serious on the whole, though there were exceptions. Fertility, especially of sheep, was somewhat low in comparison to some countries. but the rate appeared to be as much due to the low incidence of twinning as to absolute infertility. More twins may not be desirable, given the levels of feeding. Proper data on weight gains do not exist but it would appear that male lambs can be sold off at about 25-30 kilos live weight at six months without supplementary feeding,

and that, with feeding, a live weight of 50 kilos at 11 months can be achieved. But there is great variation between breeds and different breeds are kept for different purposes. For example, non-transhumant pastoralists placed a major emphasis on milk production, a large proportion of which was consumed locally.

Pastoralism can be evaluated in terms of performance per animal, or per unit of investment (including feed), labour, or rangeland. Are we using the most appropriate measure in Turan? Livestock specialists tend to stress the importance of performance per animal (for example, milk yield per lactation per ewe, daily rate of live weight gain per head). Where the most important costs (such as labour, feed, medicines, shelter) are proportional to the number of head kept, this emphasis on productivity per animal is useful. Where the most critical scarce resource is feed, however, it may be more useful to emphasise conversion efficiency (feed into milk or meat or wool) and not performance per head per day. Conversion efficiency is hard to measure. Livestock specialists argue that it correlates very closely with performance per head per day, and that selecting in terms of productivity per head is in fact tantamount to selecting for conversion efficiency. It is possible to demonstrate this correlation under conditions where ample feed is available in front of the animal's nose, but where feed is scarce and difficult to find (hidden away in crevices and under thorny bushes), the correlation may not hold, since eight legs (two small animals) may gather more food than four legs (one large). The conversion rate applicable is then not "product per feed consumed" but "product per feed available if looked for" (Sandford 1977a).

The last two paragraphs argue that, while the present performance of livestock in Turan is not impressive (whether or not it is presently causing degradation), it may not be very easy to improve it without a radical change in the level of feeding. Whether such improvement in feeding can be obtained by ecological management (that is, protecting, rotating, reseeding, etc.), or whether it would require a complete change to intensive feeding (that is, economic management), and the abandonment of the range to wildlife, is obviously a matter for discussion. But any such discussion should take into account the interests of the existing population and their value as a resource (that is, socio-political management as well as ecological management), as well as the need to determine the most productive use of the resources of dry lands in the long term.

In any case, presently it is not clear whether feed is the critical constraint on livestock production. The relatively intensive use of barley feed (an innovation originating in changes in the national economy and in the spread of motorized transport in the 1960s) suggests that it is. On the other hand, the fact that payments for the rent of sheep pens (rent for grazing has been illegal since the nationalization of rangelands in 1963) are low, a mere 3 per cent of the value of output, suggests that it is not. When they discuss reasons for limiting the size of flocks, both livestock owners and shepherds stress the shortage of labour, not of feed or forage (though they do pay close attention to the forage quality, and rights to good grazing are a major source of conflict in the area). However, it is important to remember that recent years have been good climatically, and this view could change in less favourable years.

The main pressure on existing pastoral systems in Turan appears to come from a growing scarcity of labour and the consequent rise in the cost of shepherds. In the mid-1970s transhumant pastoralism appears not to have been competing well with urban industries for labour. In Turan costs were estimated to come to 70 per cent of the value of output, and 55 per cent of total cash costs were labour costs. There are also non-cash costs such as the labour required for milking. But it could be worth while for the transhumants to abandon milking in favour of concentration on meat production, since there should be some compensatory gains in heavier weights of lambs at sale.

There appears to be some scope for increasing labour productivity in shepherding, with the implication that unless total livestock numbers could be increased (which, for ecological reasons is not likely), a lower human population would be supported by pastoral activities. Whether or not there are valid technical reasons behind the transhumants' determination of 400 as the optimum flock size, output per head of sheep could almost certainly be improved if that were decided on as a primary objective. Even if increased output per animal did not generate greater output per unit area, it might give more output per shepherd. As it is, the transhumants consider the ideal labour complement to be five shepherds for every two flocks of 400 each. (The local flocks are able to stretch their labour and expenses much further because they are not competing in urban meat markets.) Undoubtedly, additional equipment and communication devices, and more frequent watering points, could lead to reduction in the need for "assistant shepherds," and probably a 50 per cent gain in labour productivity could be achieved in

this way, although at the expense of some capital investment and higher equipment costs, and possibly more pressure on the range.

This review suggests that the outlook for transhumant pastoralism in Turan is uncertain unless productivity can be increased and shepherding made more attractive. It is uncertain both ecologically and socially. Economically, the self-employed resident mixed farmer presently does fairly well. However, the viability of mixed farming during the coming decades will depend on the stability of the local communities - the interest of the younger generation and the attraction of the cities. Apart, therefore, from arguments concerning the ecological efficiency of these two adaptations, transhumance and mixed farming, there is room for serious doubt about the social as well as the ecological survival of either, unless they are included and encouraged in long-term management and development programmes.

The question of over-grazing remains. On the basis of comparison with experience in ecologically-similar areas immediately to the north (two somewhat less arid, steppic Protected Areas known as Miandasht and eastern Khosh Yeilaq), ecologists have claimed that overgrazing has been an important factor in the history of the vegetation of Turan. Is this situation due to the fact that Turan pastoralists consistently overgraze? Shepherds and flock owners alike in Turan today deny that overgrazing can occur in the long term: they understand over-grazing; they know it would reduce their profits; therefore, they do not over-graze. However, in one particular part of the area, there is evidence that overgrazing is occurring as a conscious short-term strategy, and this is worth noting. In the early 1960s, a group of nomads whose flocks had been much reduced by the drought chose to settle in the hope that since government policy favoured the sedentarisation of nomads they would thereby attract some relief or other investment that would enable them to recover. The transhumants took advantage of their reduced circumstances and manipulated the new nationalization law and their close contacts with the central administration of the province to obtain permits to graze the areas left vacant by the nomads. Because of the commercial nature of their pastoralism the transhumants were able to adapt more efficiently to the drought conditions and build up their flocks more quickly afterwards. During the recent succession of good years, the settled nomads have built up their flocks again to the point where they are obliged to challenge the transhumants for rights to their old grazing areas. In order to make their challenge effective, they appear to have chosen to over-graze as a calculated risk.

The incidence of overgrazing, whether intended or not, appears to have varied historically in response to particular sets of circumstances but probably always, as above, derived from exogenous factors. An underlying constant has been the orientation of the pastoralist towards this basic resource - the vegetation - the nature of which is always assumed rather than demonstrated. The primary concern of the traditional pastoralist appears always to be the condition of his animals (which he considers to be his basic capital) rather than the vegetation (which he seems to assume will always recover). This concern is misunderstood, since it does in fact imply a concern for the vegetation without which the animals could not survive. But more importantly it is generally not sufficiently noticed that the vegetation is also seriously threatened by the collection of shrubs for fuel, and to a lesser extent for construction of huts and pens.

In this discussion of pastoralism in Iran, I have sought to show the relationship between a number of variables that are commonly left unrelated in the planning of pastoral development. To sum up briefly, in Turan the range has been judged by experts to be degraded and the degradation has been laid at the door of the pastoralists who are presently using the area. On the national level, pastoral products have not increased in value as fast as the cost of living and, although shepherds' wages have risen sharply, they are not high enough to compete with wages for labour at comparable levels of skill in towns (given the added attraction of urban facilities). The present result is a shortage of shepherds. But there has also been rural (as well as urban) population growth, and the animal population may have increased similarly, though there are no reliable figures. It is likely, therefore, that the stocking ratio has increased and that as a consequence herding efficiency has declined, because of lack of shepherds. This suggests that not only pressure on the range, but also the rate of degradation has increased.

As with irrigation, the perception of the planners has hindered the investigation of a number of questions that are directly relevant to the problems of ecologically- and socially-efficient pastoral development. These questions generally have to do with the definition of the problem and are of two basic types. The first concerns the significance of former practices that are no longer current. For example, there is evidence that past use of

ligneous vegetation for firewood, charcoal production, and construction has been an important factor in the composition of the present vegetation. This factor has been greatly attenuated by the introduction of paraffin and the prohibition of charcoal burning. Another example is the removal of camels from the ecosystem and their replacement by motor vehicles. The second type concerns organization and decisionmaking. Little progress has been made in the analysis of the factors involved in decision-making for the individual pastoralists or the relationship between the assessments on which they base their decisions and the assessments made in scientific paradigms.

The analysis of the state of pastoralism in relation to range quality in Turan is not complete without emphasis on two points - one social, one ecological, and both interestingly comparable to the irrigation cases above:

> (1) The problem of organization: Turan is an isolated area which, though representing some of the most favoured winter grazing in the northeastern quadrant of Iran and forming part of a single transhumant pastoral system with the best summer grazing in the mountains just north of Tehran, suffers from marginalisation. The problem is even more complex here than in the irrigation cases, because the area is used by several inter-dependent pastoral systems, of which only one, the transhumant, is economically significant at the national level. In order to deal with this problem of organization at the national level it is necessary to appreciate in detail how each system differs in terms of herd composition, range of products and markets, and to understand that they are all at the same time socially and economically inter-dependent (for example, for labour and services) and ecologically in competition for grazing.
>
> (2) The problem of information: whereas the effects of irrigation on the environment are generally known and understood. there are almost no scientific data on the interaction between different grazing animals under different herding strategies and different vegetation communities in South-west Asia.

The case of Afghanistan

Afghanistan largely shares a common cultural heritage and geographical condition with Iran. But there are some significant differences. To begin with, Afghanistan is at the opposite end of the economic scale. With no oil income it falls in the Fourth World category of the "poorest of the poor." For that reason only, pastoralism would be much more important to the national economy in Afghanistan than in Iran. But pastoralism is also more important in Afghanistan's rural economy, providing the basis not only of meat and milk supplies but of wool and skins for the karakul and carpet industries. In what is now Iran, political power has traditionally been in the hands of the settled urbanized population; in Afghanistan, power has lain with the tribes, who form the majority of the population and have a strong pastoral bias. Thus pastoralism is much better integrated in the national life generally. We might expect, therefore, that pastoral development would not encounter the same problems in Afghanistan, and that it would be approached from a more holistic, sociologically sensitive point of view. In fact, however, it seems that the poorer the country the more technocentric, or eco-centric, the planning, and that cultural heritage has very little influence.

Livestock production in Afghanistan is estimated to contribute about 30 per cent of exports. The most economically important animal in the national herd is sheep, estimated at 14 million in 1976, down from over 21 million before the drought years of the early 1970s. The major factors limiting growth in present conditions are said to be the condition of the range and the shortage of supplementary feed, especially in winter; but once again there is no adequate information on the other factors of production, and no analysis of social constraints. Although total GNP is thought to be growing at about 3.3 per cent per annum (1965-1974), per capita GNP remains the lowest in the region, at the equivalent of about US $110 (1974). Some two-thirds of the population are involved to a greater or lesser extent in livestock production (See Sandford 1977b). The development problem is not only how to raise productivity but how to harness existing production for the national economy, especially for exports. But pastoralism is accused of causing serious environmental degradation by overgrazing and therefore, it is assumed, must be changed.

In 1974 a Livestock Development Project was begun in an area of 12,000 km2 along the Hari-Rud River in the district of Herat in northwestern Afghanistan (See World Bank 1976, 1978). At the commencement of the project, there was almost no scientific information available on the ecology of the country's rangelands, the dynamics of pastoral production and marketing, or the strategies of herding and management of the traditional pastoral systems. In 1976 the second stage of the project was expanded to cover an area of 100,000 km2. The small ruminant population of this area is estimated at 2,000,000 sheep and goats, approximately half of which are owned by villages and half by transhumant families. The main focus of the project was to raise export earnings by providing a slaughter house and sheep improvement centres and integrating them into the traditional pastoral systems. A subsidiary aim was to develop cooperatives among small producers to enable them to take advantage of institutional credit facilities. The project was supported by a comprehensive research base in the natural dimension, although it is not clear that the findings of the research were used in later work. (The Project had to be discontinued in 1979 because of the deteriorating political situation.)

The project provided for a range improvement specialist responsible for the establishment and operation of a range improvement centre with field stations. But this component does not appear to be closely integrated with the major aims of the project. However, a particularly impressive part of the results of the project is a series of reports that derive from this component. These reports go into considerable detail concerning the quantity, quality and composition of range vegetation in northwestern Afghanistan and the usage patterns and organization of work in relation to it.

Although these reports constitute one of the most comprehensive sets of data available on the interaction of traditional pastoral systems and vegetation processes on arid and semi-arid ranges, and as such are an invaluable contribution to pastoral development, there is an obvious inadequacy in their coverage. Whether or not there was any conscious intent to describe and analyse the three dimensions of the system, rather than simply the ecology and the economy, the data are exclusively behavioural. They therefore fail to explain the strategies or intentions of the pastoralists. This is of course not surprising since they were gathered according to a research design that was not socio-centric and included no provision for structuring the participation of the pastoralists in the process of planning the development of their own production systems.

Even so, the data are invaluable and the addition of the perceptual perspective could make the Herat Livestock Development Project in Afghanistan a unique step toward finding solutions to the problems of pastoral development without pressing too hard against the limits of range productivity. Like the other projects discussed in this chapter, it shows how the beginnings of a process of reorientation in the study of community environment relations can produce information that will eventually transform the development effort.

This chapter has laid out some examples of ecological problems confronting development, appraised them against the background of the three-dimensional approach and set them in historical perspective, showing how in each example the implications for ecological planning change according to how the social and cultural dimensions of the problem are assessed. Special emphasis has been given to the role of external factors (exogeny) rather than internal dynamics (adaptation) in causing both historical incongruencies and modern inadequacies of planning. In each case we have sought to provide a wider perspective by means of comparison with similar examples that differ in some but not all respects. The argument for consciously interrelating ecological, social, and cultural processes in any attempts to induce change or to account for it should by now be clear, although it might be desirable to support it with more detail for which there is not space in the present work. It remains now to summarise the significance of such an approach, from both the intellectual and the practical points of view, in the final chapter.

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4. Prospective

I. A rationalization of trends

The experience of the development phase, since the 1950s, has contributed greatly to our understanding of the practical possibilities and limitations of our technology, and has brought science and engineering into closer cooperation. But our awareness of the social and cultural dimensions of human situations has lagged behind. Although the social sciences also have made progress in this period, they have had less success in raising the general level of awareness of social and cultural processes than the natural sciences have had in spreading awareness of the biological and physical world. This failure is partly due to the unprecedented rate of social and economic change, and of political disorganization and reorganization, that we have experienced in the aftermath of the Second World War and the arrival of so many new nations on the scene of international politics. The failure is also due partly the reputation (derived from our rationalist heritage) of the social sciences as "soft" sciences, and partly to the fact that they include a number of distinct approaches which, though not contradictory, are not mutually reinforcing.

The social sciences, unlike the natural sciences, break down into a number of significantly different approaches which range from the positivist and behaviourist to the mentalist and idealist. This differentiation has become more conscious in recent decades, and different approaches have displayed different degrees of innovativeness. The question of whether the social scientist is justified in striving to stand outside human society in order to study it with total objectivity has become a divisive issue. Those, probably the majority, who still maintain this positivist stance enjoy better communication with non-social scientists, to whom they can and do provide meaningful data. However, the degree to which these data prove predictive, and therefore usable in projects of application, has been disappointing. Many social scientists (probably an increasing number) accept their basic kinship with their subject matter, renounce the claim to total objectivity, and seek to study human life from the inside. In so doing they often forfeit at least some of their credibility as scientists. But there have been compensating gains (which may be found by the sympathetic reader) in their increasing success in linking the various parameters of our shared human nature and in reconstructing the processes by which ways of thinking are reinforced or transformed (See, for example, Douglas 1970, 1980; Geertz 1973; Sahlins 1976; and Turner 1974). Taken altogether, the human capability for self-awareness appears to have increased significantly in this century.

Can we capitalize on this increased self-awareness? Chapter two above points to the impact on human thought of the intensified manoeuvrings to further self-interest, to increase consciousness, and to find deeper meaning in life. The most practical aspect of this impact should be seen in an increased openness to change in conditions and ideas and an accompanying increase in flexibility in behaviour and thought (which is not to discount the contrasting phenomenon of intensified ethnic and other group conflicts that is an aspect of the manoeuvring).

The three-dimensional approach, which this essay attempts to illustrate, facilitates the complementary and optimal application of the different types of knowledge and understanding that are now available. The recognition of public policy as a yardstick and the political process as its justification ensures that application will approximate as closely as possible to the appropriate public interest though it will no doubt always be imperfect in both design and execution and that the potential moral problems of ecology and development will be subsumed in the larger moral issues of political life. Perhaps the most significant aspect of the rationalist phase of science has been the increase in precision it has afforded; it is now both possible and necessary to set

that increasing precision in a larger epistemological context by allowing the autonomous investigation of its social and cultural dimensions.

In each of the cases adduced in chapter three, three processes can be discerned:

— natural processes that are assessed by ecologists in terms of degradation;
— social processes in which different communities and different individuals within them manoeuvre, vie with each other, and manipulate their options to gain advantage in relation to what they perceive as resources, in order to safeguard or improve their standard and style of living; and
— cultural processes in which figments of experience are articulated in such a way that they transcend their immediate meaning and for a time serve as conceptual landmarks for human identity and endeavour, before they lose their appeal, and give way to others - symbols thrown up or regenerated stochastically by the interaction of continuing social and natural processes.

Natural processes work according to natural laws; social processes derive from the day-to-day interaction and arrangement between individuals pursuing their various aims in relation to each other; and cultural processes derive from the communication of ideas and perceptions and their transformation into symbols. Each type of process is generated independently, but constrained and instigated by the others. Natural processes (biological and physical) are modified by human activity. Social processes derive from demographic factors and the availability of resources, in turn dependent partly on cultural factors such as the perception of how to use materials (innovativeness) and the attribution of different values to different resources, as for instance in the determination to eat meat or to abstain from it. Cultural factors derive from the day-to-day experience of the social and the natural, which are the raw material from which ideas and symbols are generated and elaborated. "Ecology" became such a symbol in the 1960s and reached the peak of its appeal in the early 1970s.

In the Punjab the natural factors interact in a process of degradation. The negative role of the human factor is taken for granted. But if we look closer, we see instead a situation of disharmony, each element of which nevertheless has positive features. The population is organized into biradari groupings, within which and between which individuals compete in a social process for natural resources, political following, and prestige. Prestige is conceptualized as izzat, the meaning of which interacts in a cultural process in people's minds with other cultural factors such as Islamic and urban values. None of these three processes determines the others or can be entirely predicted on the basis of the other two, but each is conditioned and influenced by the others. The system is organized in such a way that the centripetality and cohesiveness of the social groupings is cancelled out by the way the population has been superimposed on the resources. But once the situation is seen in this new light the idea of harnessing the positive aspects of it is not inconceivable. Izzat is not negative per se; it works negatively in the system as presently constituted.

On the Iranian plateau the natural succession of rangeland vegetation is affected by the continual but fluctuating pressure of grazing. Grazing patterns vary according to the competition for resources in the larger economy and the strategies of local shepherds. Independently-generated changes in food preferences, the relationship of urban to rural values, the cultural perception of shepherding and of nature change the goals of the pastoralists and thus also the patterns of grazing pressure. Once again, none of these processes can be understood in terms only of one or both of the others. Moreover, the dynamics of each of the three processes are sufficiently distinct and autonomous for it not to be feasible for one scientist to do justice to the analysis and explanation of all of them in one situation. Just as they are autonomous, interacting processes, so they require autonomous but interacting advocates in their interpretation.

In the case of pastoralism, it is interesting to note that unlike irrigation - it has attracted numerous ecological studies in various disciplines among which range science and anthropology are perhaps the most conspicuous. In these studies there are two basic themes. In one, pastoralists are blamed for causing ecological damage by pursuing unscientific pastoral strategies. In the other they are shown sympathetically to be well integrated with their environment, while their cultural integrity is threatened by interventions from the larger political economy. Unfortunately, although this literature provides the basis for a new analysis of this development problem, each discipline begs questions that must be answered by the others but does little or nothing to facilitate the trans-disciplinary communication and dialogue that would generate such answers.

In postulating three processes we have cut the cake in a particular way, according to the conceptual lines of division we ourselves perceive. Natural, social, and cultural represent an existing taxonomy, which however is an arbitrary selection from among the possibilities for dividing up the various disciplinary approaches. Despite the predominance of dual, binary, opposing or dialectical conceptualizations in our intellectual heritage, the above threesome is not new. (The social may anyway be best understood as a bridge between natural and cultural.) Moreover, it has been and may be represented in a number of permutations. Foucault (1966) has explicated the biological, the social, and the cultural in history as three models of life, labour, and language, present in every epoch, though differently conceived. For him, their mode of articulation constitutes the discourse of the epoch. Religion holds them together. Reason separates them. Each historically-identifiable change in the mode. of their articulation shows a trend to increased awareness and consciousness. In an applied permutation, the same threesome appears as degradation, productivity, and welfare; in research for development, as disciplinary, administrative, and political. Finally, one can fantasize (after Uberoi) the modern equivalent of the Renaissance man as the embodiment of the three dimensions consisting in (1) the detachment of the scientist, whether physicist, biologist or orientalist; (2) the involvement of the ethnograpber, participating, absorbing, and interpreting; and (3) the commitment of the planner, purposive and deliberate.

In each of these dimensions, ecology has a different meaning. In the first it may be degradation. A mistake arising from the epistemology

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